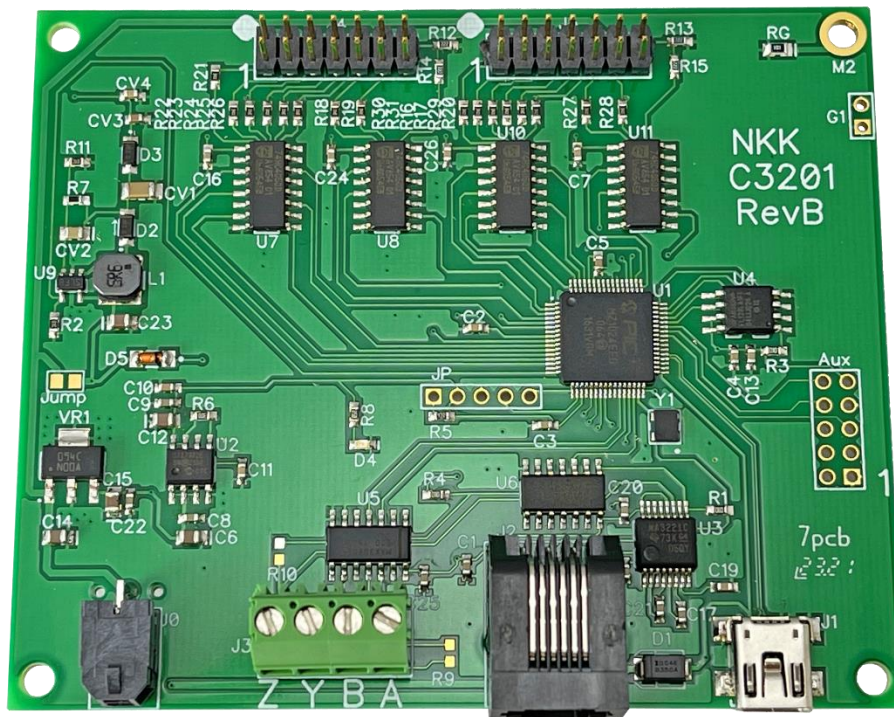


IS-C3201 Intelligent Controller User Manual

Revision C



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1. General Controller Features

The IS-C3201 controls up to 32 LCD 36x24 switches/displays. The IS-C3201 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:

- Control up to 32 LCD 36x24 switches/displays. Two banks of 16.
- USB, RS232, RS422/RS485 communication (115,200 baud).
- User downloadable images and backlight colors.
- Look up tables for fonts 5x7 and 7x10.
- 8 brightness settings.
- Memory for 16,000 images, backlights, and attributes.
- Reports switch activities via serial port.
- Stand-alone operation or real time control by host.
- A 10 pins Auxiliary port with 7 MC pins for control or sense other devices.
- User defined blinking durations.
- Firmware upgradable via USB.

Switch-action report from the controller to the host:

- On switch press/release status change, the new statuses are sent over the last communication interface.

Real-time operation features:

- Download graphic image data to any switch.
- Select any image from flash memory to display on any of switches.
- Create 6x8 font string for a specified row on a specified switch.
- Create 9x12 font string for a specified row on a specified switch.
- Change backlight color on any switch.

2. Electrical Specifications

+6.5VDC to +12VDC power, maximum current is 170mA without switches and 900mA with 32 switches.

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

3. Compatible Logic Boards

Logic Boards

Switch logic boards: PCBs with mounted switches or displays that are used for controllers are called logic boards. Based on the number of logic boards and the length of the interconnect cables, a signal booster (IS-LBUF01) may be required. All the logic boards have two 7x2 connectors and can be daisy chained via 14 pin ribbon cables. JP2 of board A gets connected to J1 of board B, and so on. The red wire of the ribbon cable, indicating pin 1, must be connected to pin 1 for all connections.

The following is a list of standard compatible logic boards. There are other logic boards available that are not listed as standard. Additionally, new logic boards can be designed based on customer requirements.

Item	Part# with Socket and switch	Part# with switch	Description
1		IS-L0107-IS15BBFB4PRGB	Logic Board, LCD 36x24 RGB, 1SW. Panel Mount
2	IS-L0204-CS	IS-L0204-S	LOGIC BOARD, 1x2, LCD 36x24 RGB, 2SW. Side by side stackable
3	IS-L0271-CS	IS-L0271-S	LOGIC BOARD, 1x2, Compact LCD 36x24 RGB, 2SW. Side by side stackable
4	IS-L0403-CS	IS-L0403-S	LOGIC BOARD, 2x2, LCD 36x24 RGB, 4SW. Side by side stackable
5	IS-L1602-CS	IS-L1602-S	LOGIC BOARD, 4x4, LCD 36x24 RGB, 16SW. 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.

Signal Booster

This Logic Board signal booster may be needed when more than 10 logic boards are daisy chained or for long cable lengths.

Item	Part #	Description
1	IS-LBUF01	Signal Booster for Logic Boards

Ribbon Cables

These cables are used for connecting logic boards and the controller. Custom length cables can be made to order.

Item	Part#	Length	Description
1	ISDCB81.2	1.2"	RIBBON CABLE, 14 CONDUCTORS, 28AWG, .050"
2	ISDCB83	3"	RIBBON CABLE, 14 CONDUCTORS, 28AWG, .050"
3	ISDCB88	8"	RIBBON CABLE, 14 CONDUCTORS, 28AWG, .050"
4	ISDCB812	12"	RIBBON CABLE, 14 CONDUCTORS, 28AWG, .050"
5	ISDCB824	24"	RIBBON CABLE, 14 CONDUCTORS, 28AWG, .050"
6	ISDCB836	36"	RIBBON CABLE, 14 CONDUCTORS, 28AWG, .050"

4. Operational Detail

Power-up Sequence:

The system loads image, backlight, and attribute data from flash memory for 32 switches (even if the switches are not physically present). Switches 0-15 are connected to J4, and switches 16-31 are connected to J5. Images, attributes, and backlight addresses 1-32 are loaded to switches 0-31, respectively. The system then waits for a button press or host command while scanning for switch presses. Images, backlight, and attribute data are stored in separate sections of memory, so erasing the image data will not remove the other data.

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

Main Operational Mode:

The controller waits for input or a host command. It will send the following bytes for a switch activity:

50 AA AA AA AA AA AA AA AA

The 0x50 signifies a switch response. The AAs are the 32-bit switch number mask encoded in ASCII hex, and represent what switches are pressed. Each bit represents the corresponding switch, and a high bit is pressed while a low bit is not pressed. The number is $(1 \ll \text{switch_press})$.

Example response: 50 32 31 30 30 34 30 30 33

32 31 30 30 34 30 30 33 converted from ASCII hex is 0x21004003 (0b00100001 00000000 01000000 00000011). Bits 0, 1, 14, 23, and 29 are high, meaning switches 1, 2, 15, 24, and 30 are all pressed. (Switch numbers are 0-indexed). Examples of single switch presses are:

00000000	No switch pressed
00000001	Switch 0 pressed
00000002	Switch 1 pressed
00000004	Switch 2 pressed
00000008	Switch 3 pressed
00000010	Switch 4 pressed
00000020	Switch 5 pressed
00000040	Switch 6 pressed
00000080	Switch 7 pressed
00000100	Switch 8 pressed
00000200	Switch 9 pressed
00000400	Switch 10 pressed
00000800	Switch 11 pressed
00001000	Switch 12 pressed
00002000	Switch 13 pressed
00004000	Switch 14 pressed

00008000	Switch 15 pressed
00010000	Switch 16 pressed
00020000	Switch 17 pressed
00040000	Switch 18 pressed
00080000	Switch 19 pressed
00100000	Switch 20 pressed
00200000	Switch 21 pressed
00400000	Switch 22 pressed
00800000	Switch 23 pressed
01000000	Switch 24 pressed
02000000	Switch 25 pressed
04000000	Switch 26 pressed
08000000	Switch 27 pressed
10000000	Switch 28 pressed
20000000	Switch 29 pressed
40000000	Switch 30 pressed
80000000	Switch 31 pressed

LED Backlighting:

An LED code is one byte, where the low nibble of the byte is the ON cycle and high nibble is the OFF cycle. The format for both nibbles is the same. The following is the byte format:

	OFF Cycle Nibble				ON Cycle Nibble			
Bit	7	6	5	4	3	2	1	0
Color	X	B	G	R	X	B	G	R

Nibble Value	Color
0	Off
1	Red
2	Green
3	Yellow
4	Blue
5	Magenta
6	Teal
7	White

The system defaults to using the OFF cycle only unless a duration was sent previously using the “set backlight duration” command. See the associated command list for details.

The backlight brightness can be adjusted using the “change brightness” command. See the associated command list for details.

Attributes:

Attributes determine system behavior when a button is pressed. Each switch is assigned an address on startup (1-32). Each address has image, backlight, and attribute information. The attribute determines what new address every switch in the system changes to (if any). When a switch is pressed, the attribute from the address of the image being displayed is executed.

The attributes are user defined and downloaded either using Engineering Kits Communicator from an Excel file or manually using the command. See the associated command list for attribute examples and formatting.

5. Communication Protocol

The controller communicates with the host by USB, RS232 (115,200 baud), or R422. The commands and responses are the same regardless of protocol. One command should be transmitted at the time. If multiple commands sent at the same time only the first one gets executed and the rest are ignored.

- RS232/422: 115K, 8bit no parity, one stop bit.
- The USB communicates over a virtual comm port with the same settings as RS232.

The command behavior is:

- 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. One-byte commands do not transmit 79H. See the associated command list.
- If the byte is not a command, it is ignored.

When the controller expects additional information:

- A timer is set. If the expected data bytes are not received, the controller transmits 6EH and terminates the routine.
- 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 01H, 20H to 2FH and are transmitted in hex format. The controller transmits 61H upon receiving of any of the command byte stated above. When a command has more bytes associated as options or data then the controller transmit 79H upon completion of the command. If a command requires the controller to transmit information, the information will be transmitted after 61H and before 79H. The proper format for all command options and data is specified in the associated command list.

An ASCII Hex byte is a normal hex byte split in two halves and converted to their ASCII equivalent (www.asciitable.com). This is a safety measure so that all data sent is not accidentally interpreted as a command. Most data sent after commands and sub-commands are encoded in ASCII Hex.

Conversion TO ASCII Hex: $x = ((data \& 0xF0) \gg 4)$ $y = ((data \& 0x0F) \gg 0)$ if $(0x0 \leq x \leq 0x9)$ $x += 0x30$ if $(0xA \leq x \leq 0xF)$ $x += 0x37$ if $(0x0 \leq y \leq 0x9)$ $y += 0x30$ if $(0xA \leq y \leq 0xF)$ $y += 0x37$	Conversion FROM ASCII Hex: $x = \text{ASCII hex byte 1}$ $y = \text{ASCII hex byte 2 (conversion not shown)}$ $z = \text{converted byte}$ if $(0x30 \leq x \leq 0x39)$ $x -= 0x30$ if $(0x41 \leq x \leq 0x46)$ $x -= 0x37$ $z = (x \ll 4) + y$
---	--

Image Format

Images are 36x24 monochrome .bmp files. They can be created in Microsoft Paint or any image software. Images should be sent using NKK's Engineering Kits Communicator program. It extracts the 120-byte image data and encodes it in ASCII hex, so 240 bytes will be sent over USB/RS232/RS422 serial.

If you want to download the image with different software the image format is described in the table below.

	Left of image				Right of image
Line #1	Byte# 1	Byte# 2	Byte# 3	Byte# 4	Byte# 5
Line #2	Byte# 6	Byte# 7	Byte# 8	Byte# 9	Byte# 10
Line #23	Byte# 111	Byte# 112	Byte# 113	Byte# 114	Byte# 115
Line #24	Byte# 116	Byte# 117	Byte# 118	Byte# 119	Byte# 120

Images, Attributes, and Backlight Numbering

All images, attributes, and backlight numberings are inherently linked together. E.g., image 0001 corresponds with backlight 0001 and attribute 0001, image 0002 corresponds with backlight 0002 and attribute 0002, and so on. Care should be taken when ordering images, attributes, and backlights to send so that the desired behaviors are grouped together.

Switch Numbering

Switch indexes are 0 based, 0-15 (0x00-0x0F) are connected to the J4 connector, 16-31 (0x10-0x1F) are connected to the J5 connector. Switch index 16 would equal switch 1 on the J5 connector.

Attributes

An example attribute is shown on a different tab of the command list spreadsheet. For no switch change, address FFFF should be used.

Backlights

Backlights by default are on the OFF cycle. If blinking is required, send the backlight duration command to set how long the ON and OFF cycles are. The system will switch between the two states at the designated time periods.

Flash Memory

The flash memory holds up to 16k images, backlights, and attributes. The flash memory is NOR flash, which means that it needs to be erased before new data is written. Erasing flash memory sets all the bits high. Writing to flash memory only changes a high bit low. Writing the same information does not require erasing. However, if the information is changed the flash should be erased. The images, backlight, and attribute data are saved in different regions of flash memory. There are commands to erase the entire flash or individual regions.

6. Commands

Refer to IS-C3201 Command List.xlsx for the full list of commands and examples.

7. Saving Images/Attributes using Engineering Kits Communicator

The Engineering Kits Communicator program is also compatible with IS-C3201. It can be downloaded from our website at: <https://www.nkkswitches.com/download-software/>
For more details, refer to the Engineering Kits Communicator user manual.

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

To save images to the system:

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

If writing custom software to save images, all data after the command must be sent in ASCII hex.

To save attributes to the system:

1. Click the 'Excel File' button.
2. Select the Excel from your PC.
3. Wait for the upload to finish.

Refer to the Engineering Kits Communicator user manual for a full list of features and more information on attributes and images.

8. Updating with New Firmware

The IS-C3201 firmware is field upgradable via USB and can be modified to meet customer specifications. The standard IS-C3201 firmware will continue to receive firmware upgrades with added features and bug fixes. The latest command list document will show the latest firmware version available. Major firmware releases will also be shown in the change log at the bottom of this document. Each controller can display the latest firmware version applied with the associated command. See the command list for more details.

If you would like a copy of the latest firmware, please email engineering@nkkswitches.com.

The firmware is distributed as a .hex file. To update IS-C3201 with a hex file, you will need the NKK Firmware Update Utility. To get a free download of the program, please email engineering@nkkswitches.com.

Refer to the NKK Firmware Update Utility guide that comes with the download for instructions on how to update new firmware. A summary of the procedure is below:

To update the firmware:

1. Connect IS-C3201 to a PC via USB.
2. Open the NKK Firmware Update Utility.
3. If 'NOT IN BOOT MODE' message is displayed at the top, click the 'Reconnect' button.
4. The boot firmware version and COM connected messages should be displayed at the top.
5. Click the 'Erase All Firmware' button and wait for the 'Complete' message.
6. Click the 'Load File' button.
7. Select the hex file from your PC.
8. Click the 'Send New Firmware' button and wait for the 'Complete' message.

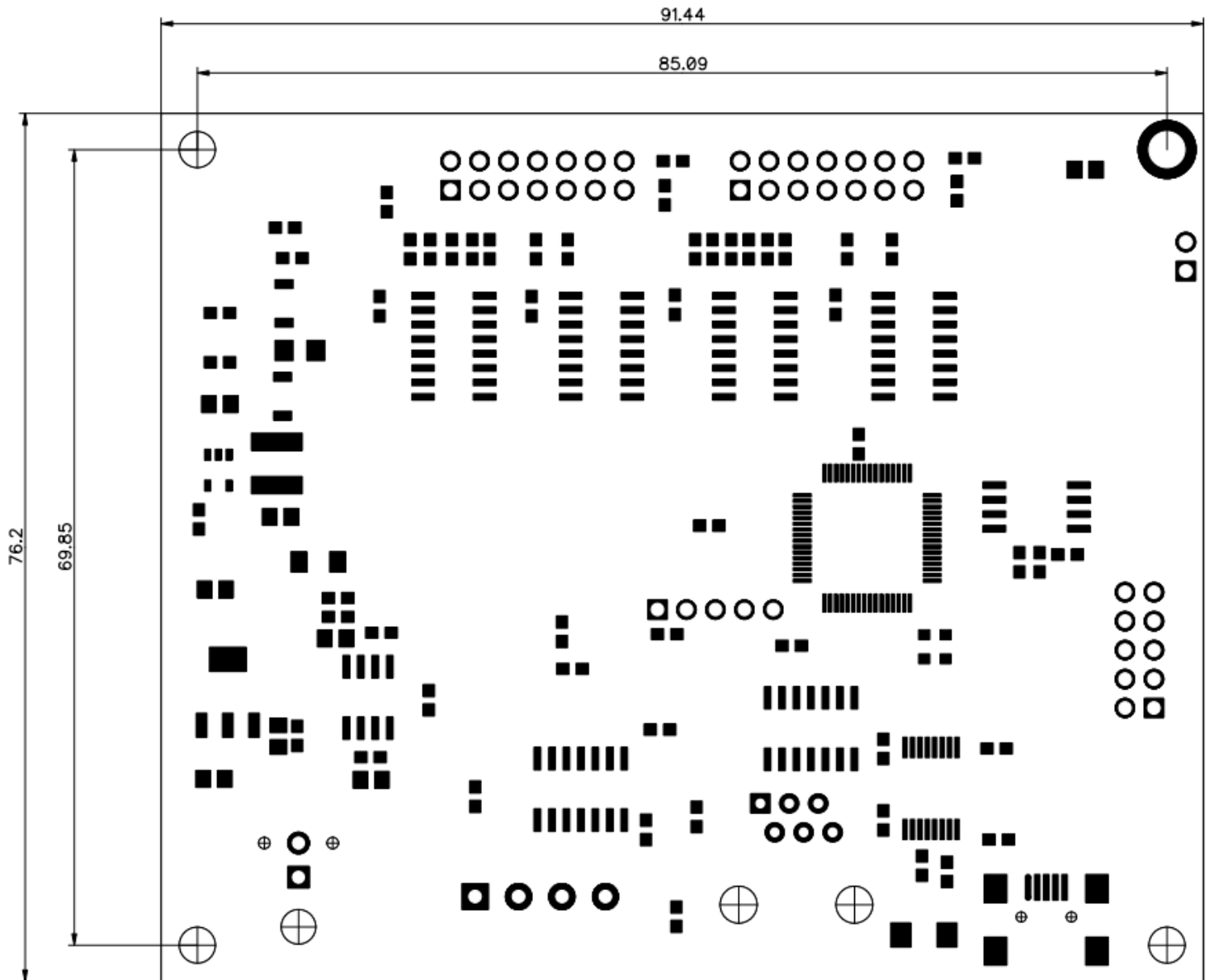
Make sure the IS-C3201 is not connected to Engineering Kits Communicator via COM port when using the NKK Firmware Update Utility and vice versa. The COM port can only be connected to one program at a time.

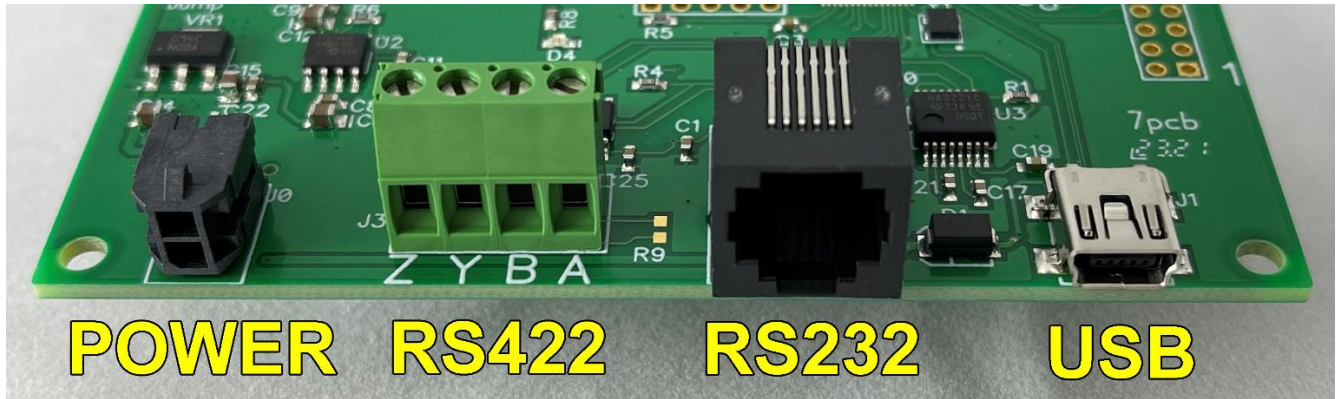
9. Hardware

Dimensions

Dimension: Board size: 3.6" x 3.0" (91.44 x 76.2 mm)

Mounting hole size: 0.125" (3.175 mm)



Connectors:

Power Connector: Molex 0430450200, top position power, bottom position ground.

Mating: Molex 0430250208

RS422 Connector: TE Connectivity 284392-4

Mating: Bare wire

RS485 Connector: TE Connectivity 284392-4 (R8&R9 have to be populated)

Mating: Bare wire

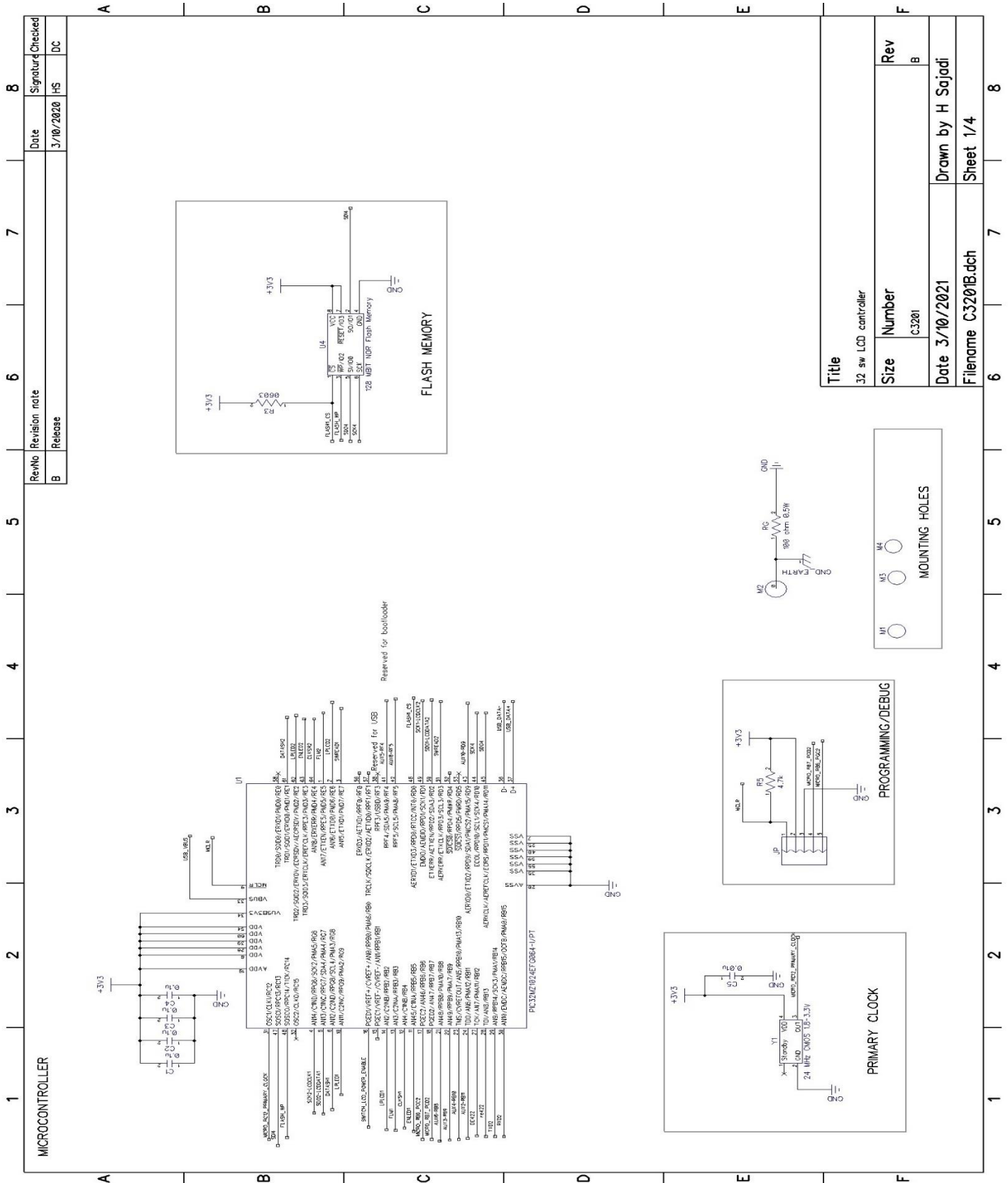
RS232 Connector: TE Connectivity 5555165-1

Mating: RJ25 connector

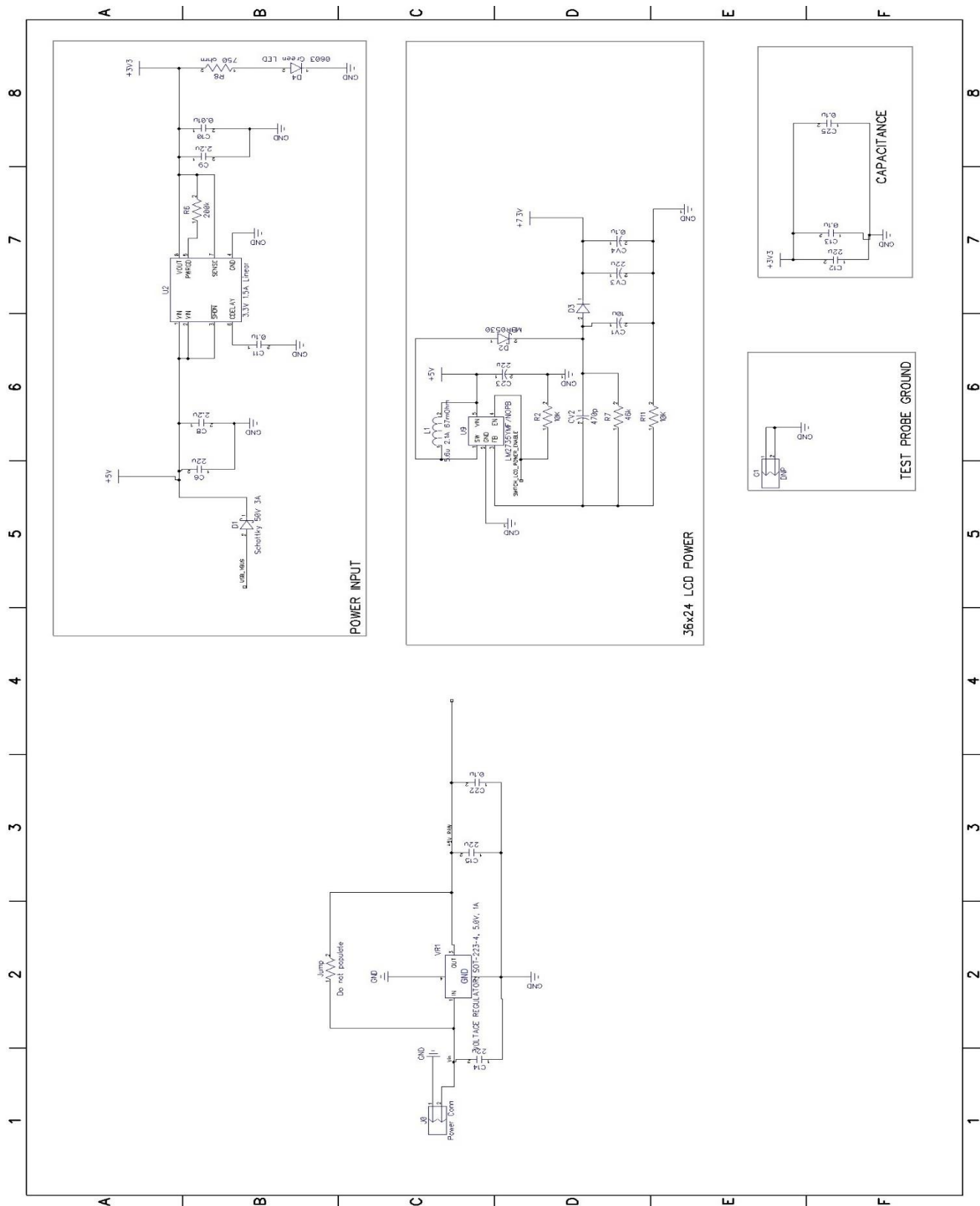
USB: TE Connectivity 1734035-2

Mating: USB Mini B

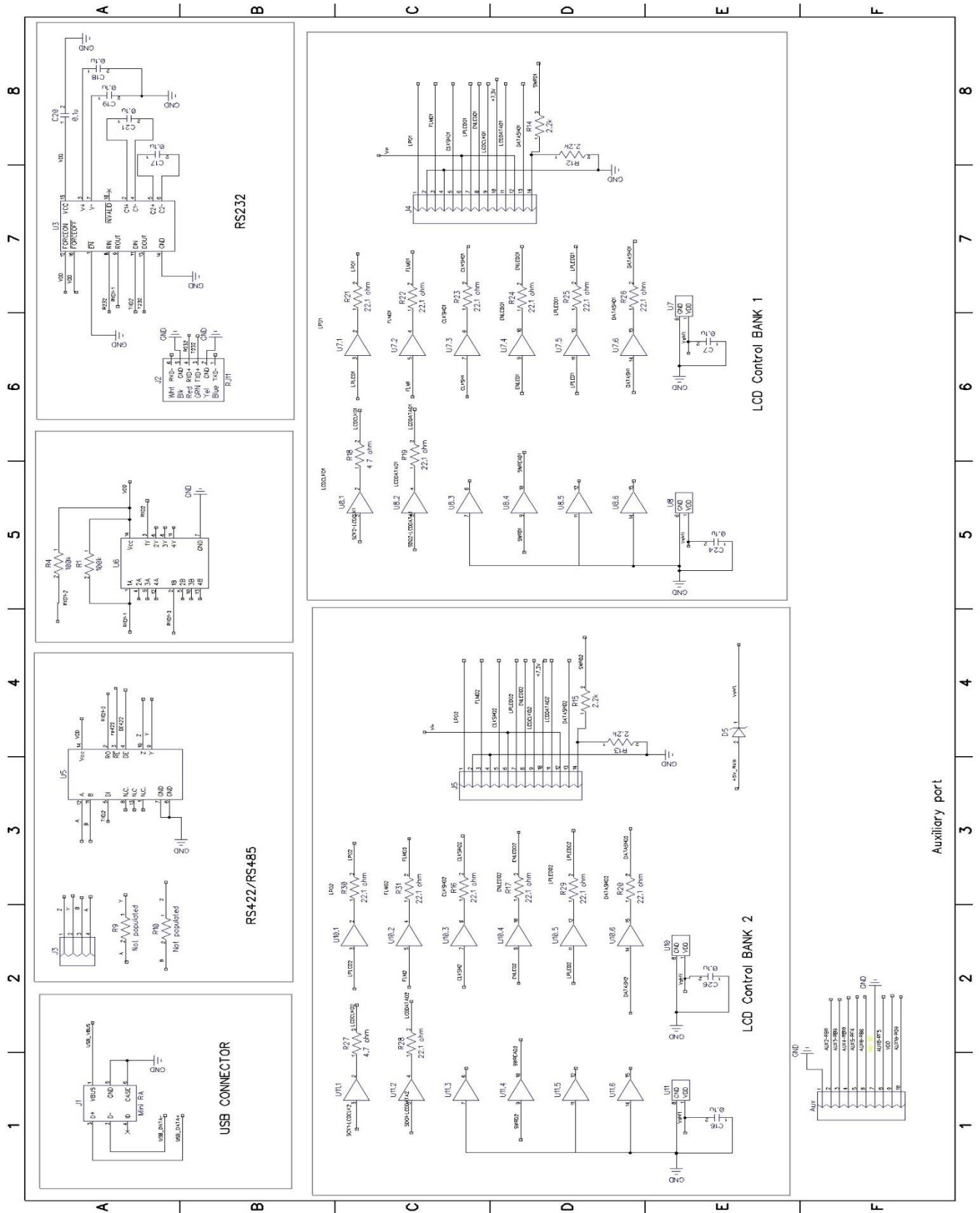
Controller Schematic



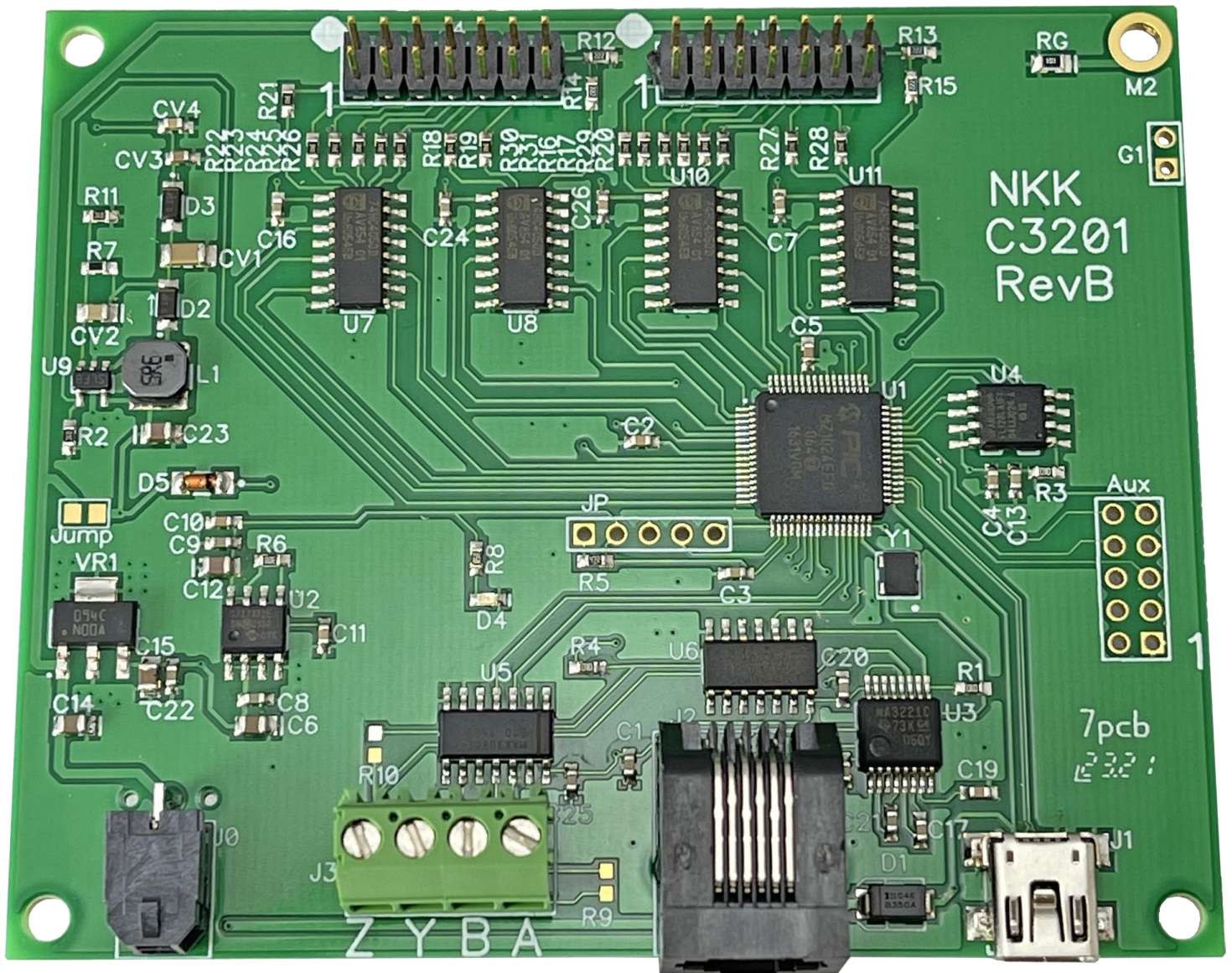
Controller Schematic (continued)



Controller Schematic (continued)



Board photo



10.Key Terms & Definitions

Host:

Any computer, terminal, or other device that sends commands over USB, RS232, or RS422.

Controller:

A PCB with a microcontroller that controls one or more logic boards

Logic board:

A PCB with one or more SmartDisplays that can be daisy chained

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.

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.

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:

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

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.

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: $2 \times 256 = 512$

Digit 2: $(10) \times 16 = 160$

Digit 1: $7 \times 1 = 7$

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

Warranty

NKK SWITCHES LIMITED WARRANTY AND LIMITATION OF LIABILITY

The following limits our liability. Please read.

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

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



Firmware Change Log

IS-C3201v0001.0023

Released April 14th 2023

- Added new command for adding characters to an entire switch
- Added new command for adding characters to multiple switches
- Added more error checking for most commands