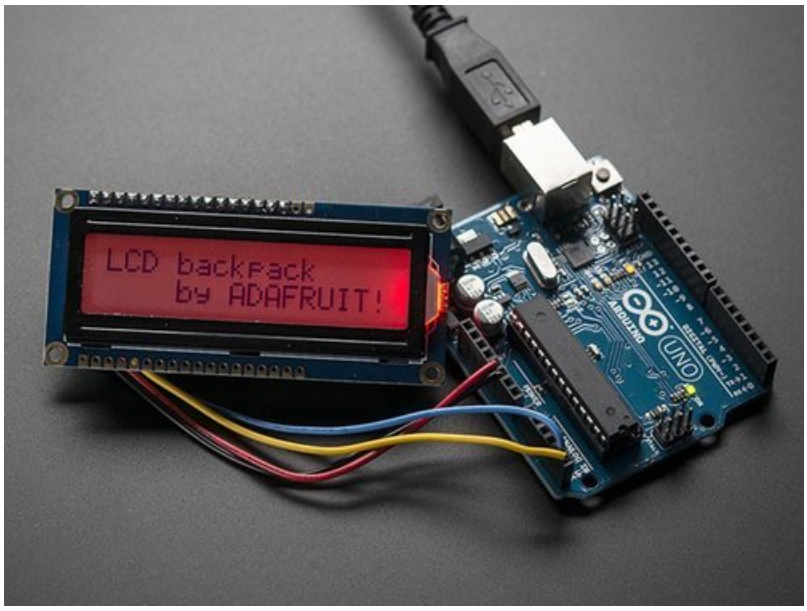
adafruit learning system

i2c/SPI LCD Backpack

Created by lady ada



Last updated on 2018-11-22 12:41:45 AM UTC

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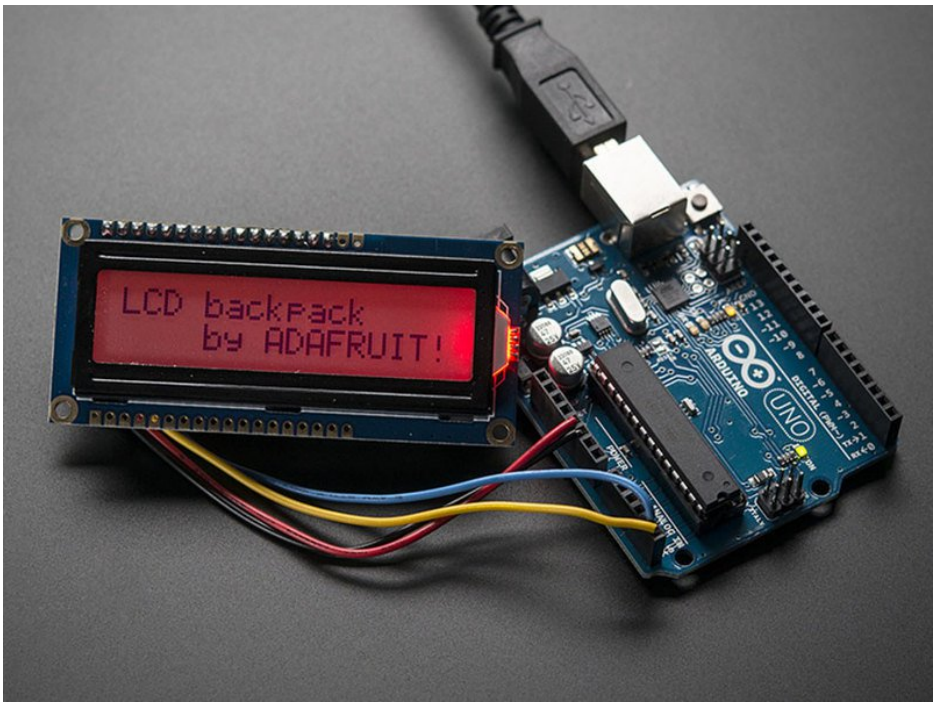
Overview



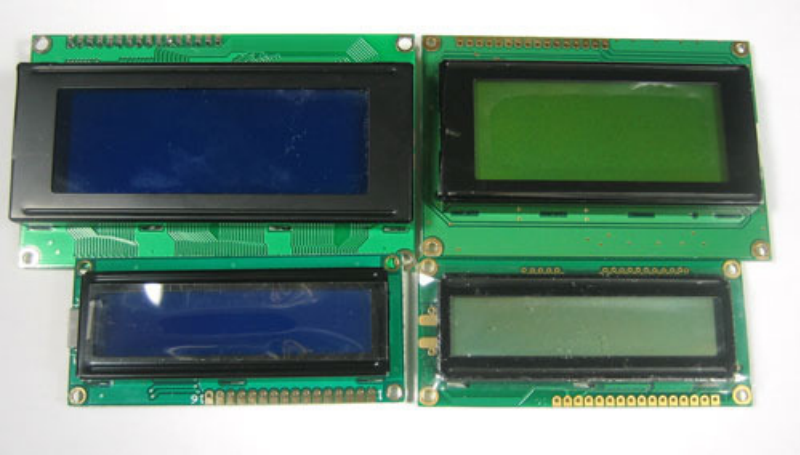
LCDs are a fun and easy way to have your microcontroller project talk back to you. Character LCDs are common, and easy to get, available in tons of colors and sizes. We've written tutorials on using character LCDs with an Arduino (https://adafru.it/c8r) (or similar microcontroller) but find that the number of pins necessary to control the LCD can be restrictive, especially with ambitious projects. We wanted to make a 'backpack' (add-on circuit) that would reduce the number of pins without a lot of expense.

By using simple i2c and SPI input/output expanders we have reduced the number of pins (only 2 pins are needed for i2c) while still making it easy to interface with the LCD. For Arduino users, we provide a easy-to-use library that is backwards compatible with projects using the '6 pin' wiring.

For advanced users, this project can be used for general purpose I/O expansion, the MCP23008 has 8 i/o pins (7 are connected) with optional pullups, the SPI 74HC595 has 7 outputs.

Assembled and tested backpacks are available for purchase for only $10 in the Adafruit shop!

Which LCD to Use?



This backpack will work with any 'standard'/'classic' **character** LCD. It does not work with **graphic** LCDs. Character LCDs come in sizes ranging from 8x1 (8 characters, one line) to 40x4 (40 characters, four lines). The backpack will also only fit LCDs that have a single line of pins at the top, not the ones that have a 2x10 or 2x8 connector on the side. Those are much rarer these days but just keep a look out for that!

The backpack will work with RGB LCDs (but wont control the RGB backlight, you can do that seperately from the LCD control) and it won't work with 40x4 LCDs because they have a second Enable pin.

Wait - the backpack has 16 holes, but my LCD only has 14 pins!

As long as your LCD has a HD44780 driver chip, you're OK. The extra two pins are for the backlight. Your LCD doesn't have a backlight.

We'll show you which holes to ignore in the Assembly section of this guide.

Assembly

Putting together the backpack onto an LCD is a quick process, and should take only a few minutes with a soldering iron.

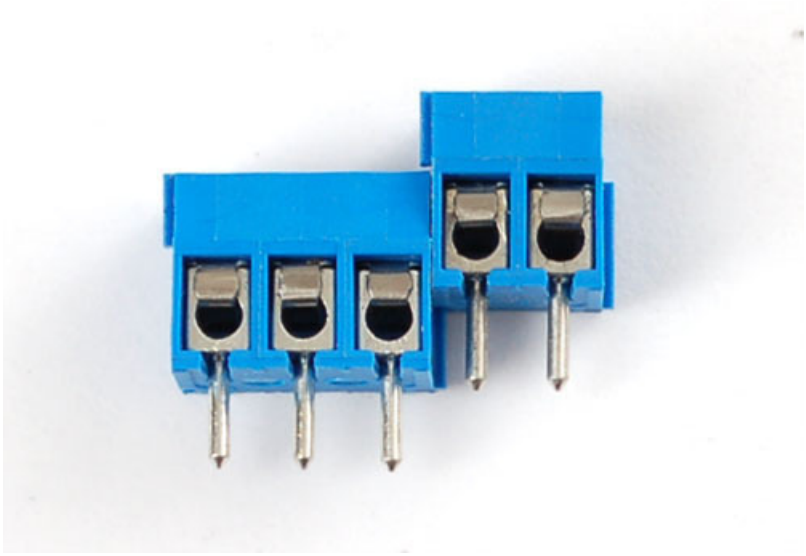
Parts Check

Verify you have everything in the bag, there should be an assembled and tested PCB, a 2-pin and 3-pin 3.5mm terminal block. The backpack does not come with header or an LCD.

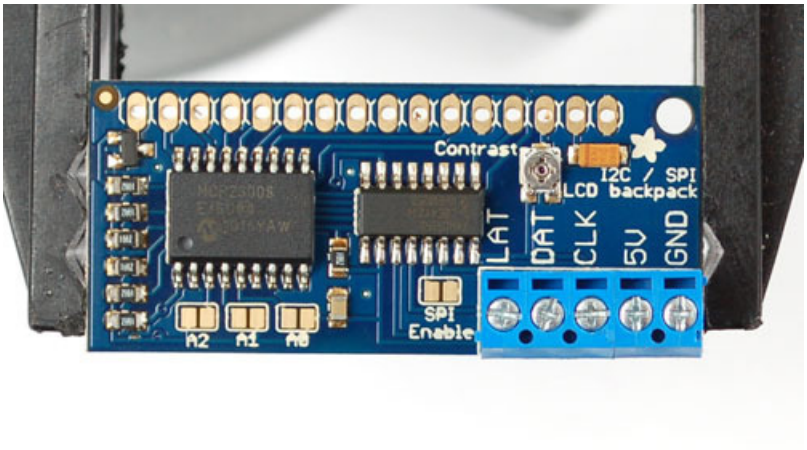
Terminal Blocks

The terminal blocks (https://adafru.it/cuW) allow you to easily attach and remove the LCD from your wiring, which we think is awfully handy. If you dont want the terminal blocks (they stick out a bit) you can always skip this step.

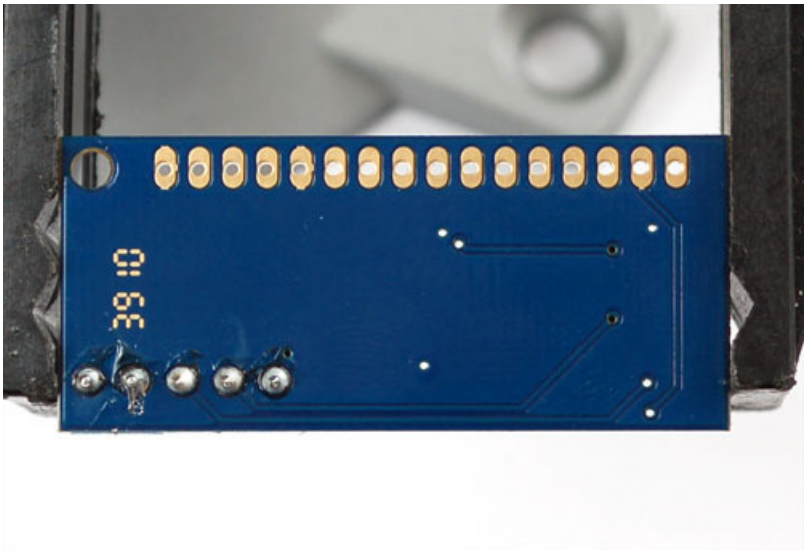
The terminal blocks come in 2 and 3-pin pieces (https://adafru.it/cuW) . Slide them together.



Place the blocks over the corner area of the backpack so that the holes stick out (unless for some reason you want them to face the other way)



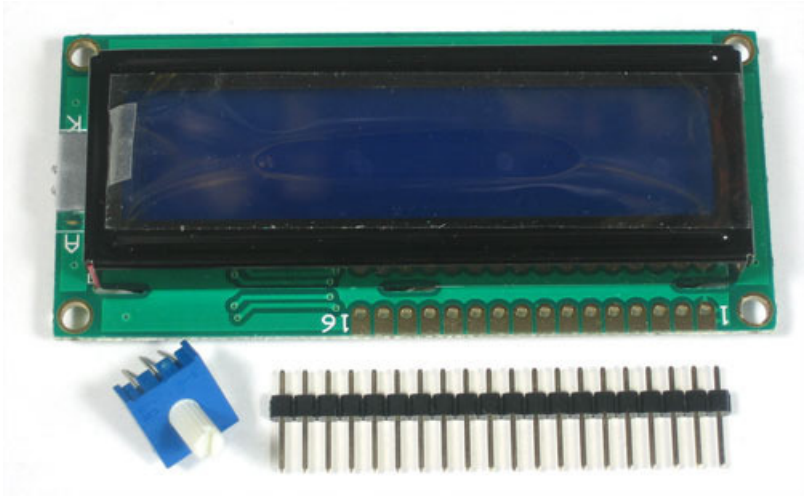
Solder them into place



Prepare LCD

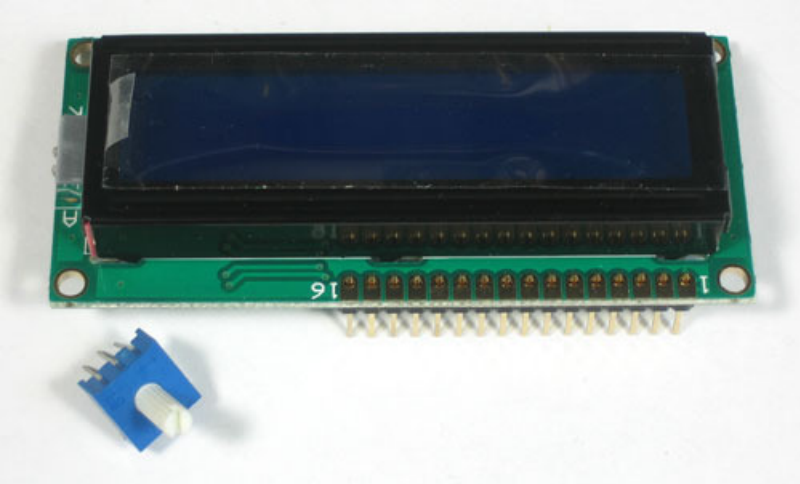
Next we will attach the backpack to the LCD. First we must put header onto the LCD, if you bought the LCD from us, it will come with a stick of header. Otherwise, pick up some standard 0.1" male header (https://adafru.it/cuX)

These photos shows a 10K potentiometer, you can ignore it

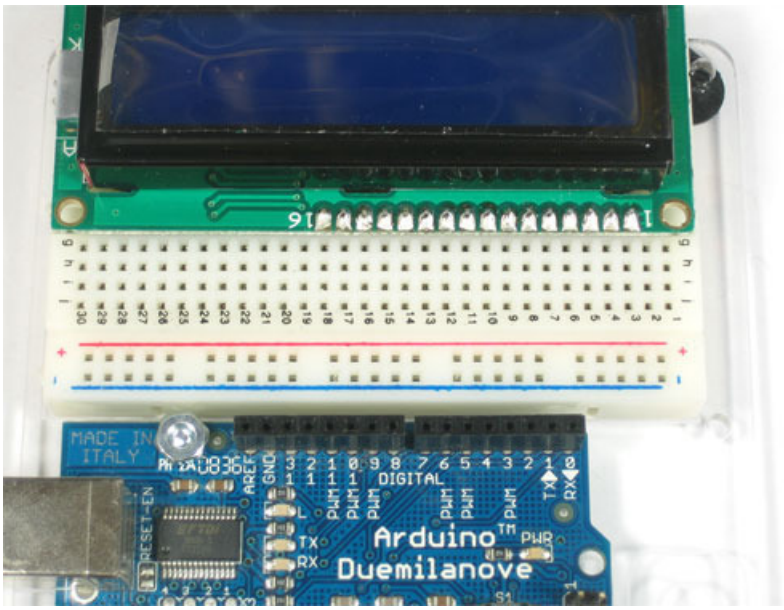


If the header is too long, just cut/snap it short so that it is 16 pins

Next you'll need to solder the header to the LCD.You must do this, it is not OK to just try to 'press fit' the LCD!



The easiest way we know of doing this is sticking the header into a breadboard and then sitting the LCD on top while soldering. this keeps it steady.

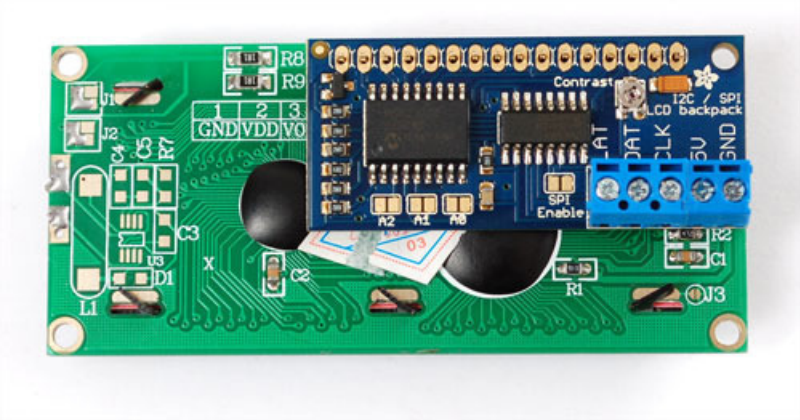


Attach LCD

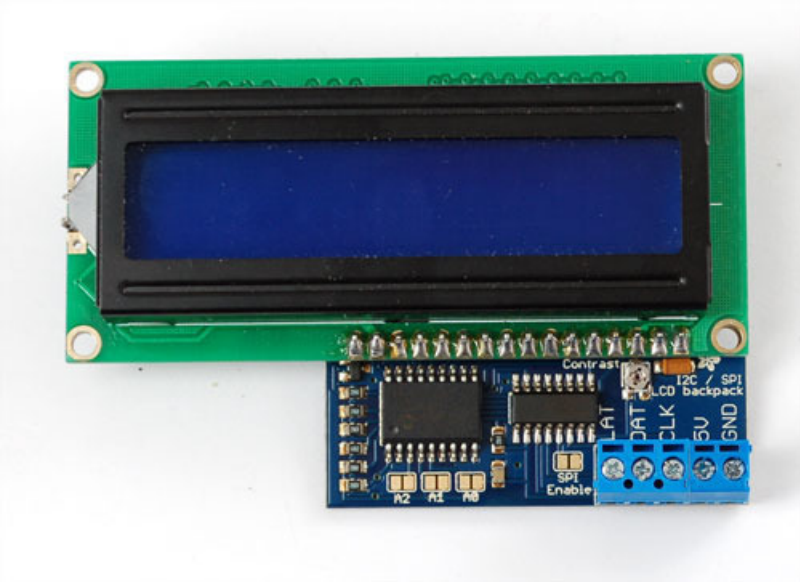
Now we will attach the backpack. We will show how to do this in a permanent fashion. If you think you would like to remove and replace the LCD at some time, you can use a piece of 16-pin long 0.1" female header (https://adafru.it/cuX) as a socket but be aware it will stick out a lot.

There are two options, you can tuck the backpack behind the LCD

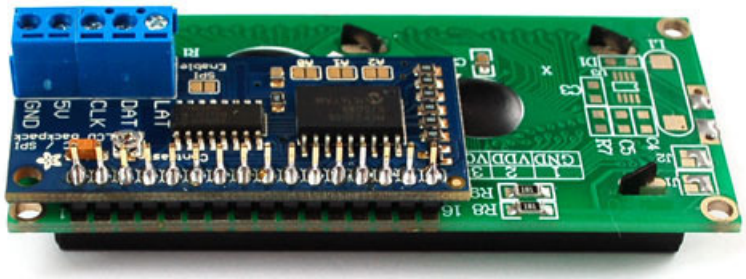
> Make sure that you line up pin 1 of the backpack with pin 1 of the display. Pin 1 is on the right side of the backpack closest to the Adafruit logo. Pin one of the display should be marked. When correctly installed, the blue terminal block will be close to the edge of the display.



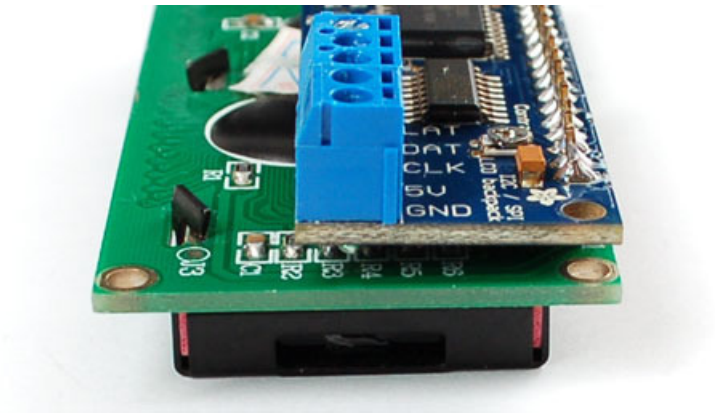
Or solder it so it's to the side, this way it's thinner.



Solder the header to the backpack.



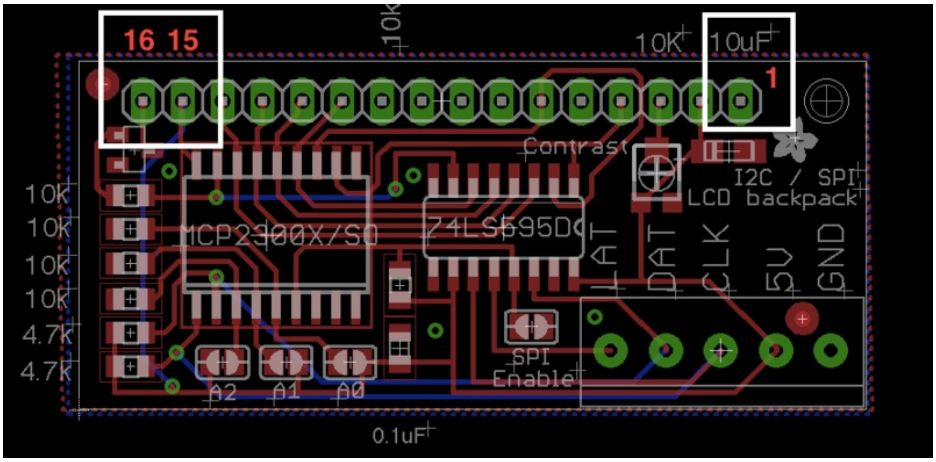
Make sure that as you solder the first pin, the backpack PCB isn't leaning against the LCD, where the terminal blocks could short against some components. You can put some electrical tape or foam tape behind to avoid this if you think it could be an issue.



That's it!

My LCD only has 14 pins. Which holes do I use?

The extra two pins are for the backlight. Your LCD doesn't have a backlight. Here's a picture of the backpack board layout, with pins 15 and 16 located. Just leave those empty. Cut the pin header down to 14 pins instead of 16, and attach your LCD to holes 1-14 in the backpack.

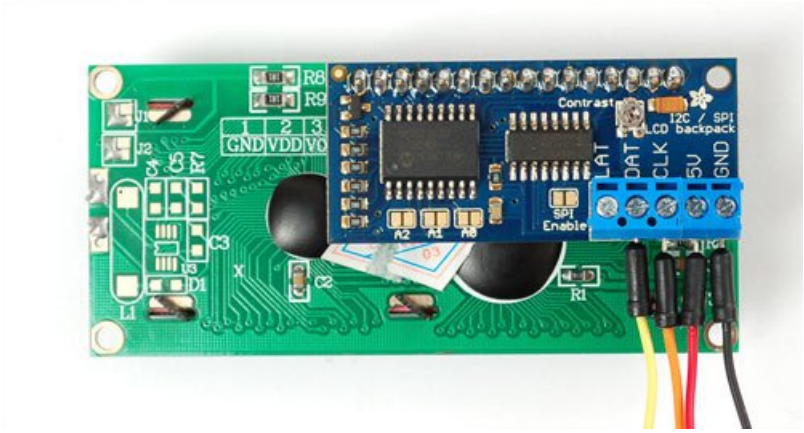


If your LCD has 18 pins, you won't be able to use the extra backlight pins, just connect 1-16 and leave 17 and 18 disconnected

Arduino I2C Use

The first option we'll show is how to use the i2c interface on the backpack. We'll be showing how to connect with an Arduino, for other microcontrollers please see our MCP23008 library code for the commands to send to the i2c i/o expander. I2c is nice because it only uses two pins, and you can put multiple i2c devices on the same two pins. So for example, you could have up to 8 LCD backpacks+LCDs all on two pins! The bad news is that you have to use the 'hardware' i2c pin. You can't change those pins and you can't use them for reading analog data. If you absolutely need those two pins, use SPI (see next section)

For this we'll need to connnect four wires: GND, 5V, CLK (clock) and DAT (data).



Connect:

- **5V** to your **5V** power pin - don't use 3.3V power, the LCD needs 5V for contrast! The I2C pullups are fairly weak so you can use use 3.3V logic for SDA/SCL even if the board is powered with 5V
- **GND** to **Ground**
- **DAT (SDA)** to I2C Data (on the Uno, this is **A4** on the Mega it is **20** and on the Leonardo digital **2**)
- **CLK (SCL)** to I2C Clock (on the Uno, this is **A5** on the Mega it is **21** and on the Leonardo digital **3**)

Install Adafruit_LiquidCrystal

To begin reading sensor data, you will need to download the Adafruit_LiquidCrystal libary from our github (https://adafru.it/leO). You can do that by visiting the github repo and manually downloading or, easier, just click this button to download the zip

https://adafru.it/yxc

https://adafru.it/yxc

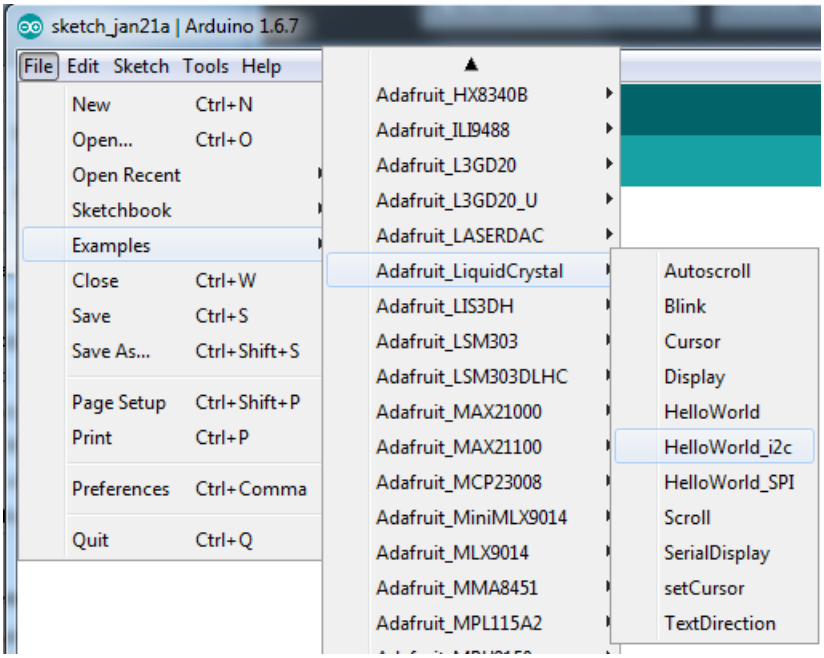
Rename the uncompressed folder **Adafruit_LiquidCrystal** and check that the **Adafruit_LiquidCrystal** folder contains **Adafruit_LiquidCrystal.cpp** and **Adafruit_LiquidCrystal.h**

Place the **Adafruit_LiquidCrystal** library folder your **arduinosketchfolder/libraries/** folder.
You may need to create the **libraries** subfolder if its your first library. Restart the IDE.

We also have a great tutorial on Arduino library installation at:
http://learn.adafruit.com/adafruit-all-about-arduino-libraries-install-use (https://adafru.it/aYM)

Load Demo

Restart the IDE and load up the **Adafruit_LiquidCrystal->HelloWorld_i2c** demo



Upload the sketch. You should see the backlight turn on when the Arduino resets. If you don't see any characters, adjust the **Contrast** trim potentiometer with a mini-screwdriver until you see the text clearly

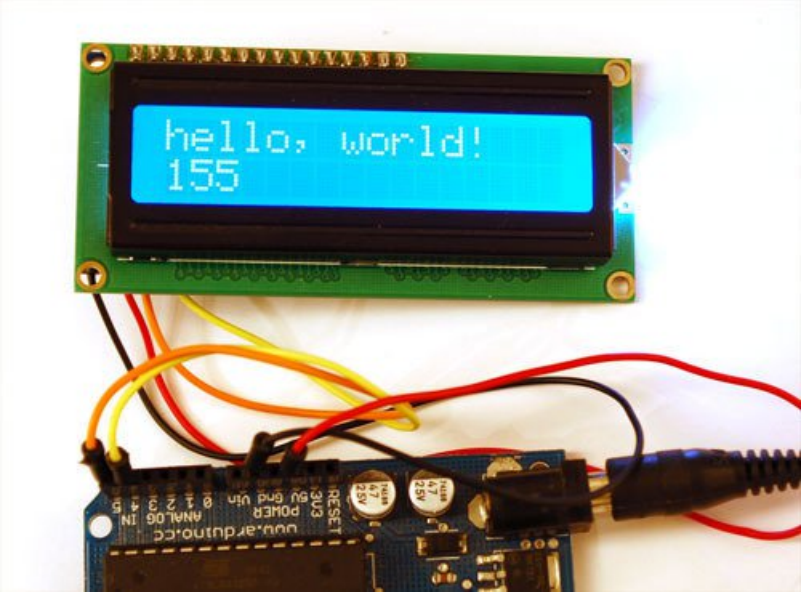
The default HelloWorld sketch blinks the backlight as well as updating the text.

If you see the backlight blinking that means your connection to the i2c port is OK but the contrast is too low or too high, or the LCD data pins are not solidly connected.

Check the contrast first by gently twisting the mini trim potentiometer, if that doesn't help, recheck your soldering and resolder all 16 of the LCD pins!

Once you're done, you can remove the blinking LED backlight code:

```
lcd.setBacklight(HIGH);
delay(500);
lcd.setBacklight(LOW);
delay(500);
```



Changing the I2C Address

If you want to have more than one MCP23008 device (like more than one backpack+LCD) each one needs to have a unique 'address'. You can set the address by jumpering the **A0 A1** and **A2** solder jumpers. By default, no jumpers are soldered, giving an address of **0**. If you want to have an address of **3** you would solder **A0** (bit 0) and **A1** (bit 1) for an address of "011" = 3 in binary. Then in the code change:

```
// Connect via i2c, default address #0 (A0-A2 not jumpered)
LiquidCrystal lcd(0);
```

to

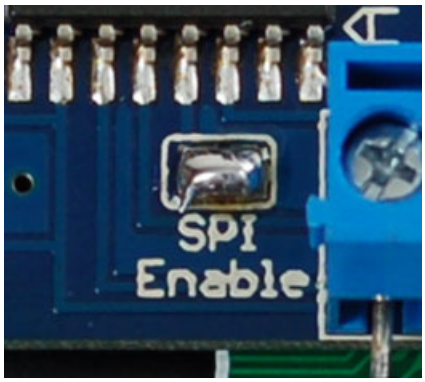
```
// Connect via i2c, address #3 (A0&A1 jumpered)
LiquidCrystal lcd(3);
```

Arduino SPI Use

Another option for connecting is to use **SPI**, which is a simpler protocol. The good news about SPI is that its very simple and you can use **any** 3 pins to connect. You can share the **data** and **clock** pins with another device as long as they remain outputs, the **latch** pin should only be used for the backpack. So if you wanted 3 LCDs, for example, they would all have the same **data** and **clock** pins, but the **latch** pin would be different, for 5 pins total

> This library does not use the Hardware SPI library, which means you can use any 3 pins! However, if you are using the hardware SPI port (such as for Ethernet, WiFi, an LCD, etc. etc) you cannot share those pins with this LCD!

The first thing you will need to do is to enable SPI. To do this, solder the **SPI Enable** solder jumper by heating up the pads with a soldering iron and soldering a blob onto both pins:



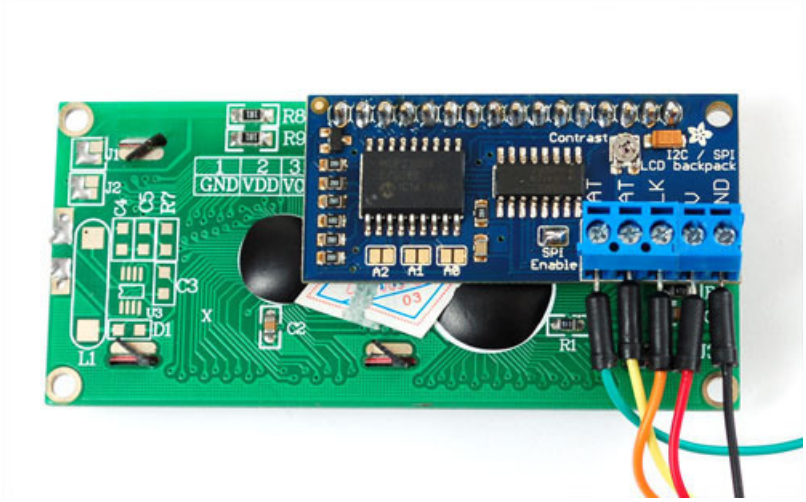
This will switch the backpack over to SPI mode instead of i2c. If you want to go back to i2c, use wick or a solder sucker to remove the jumper

Next we will connect 5 wires, **5V**, **GND**, **DAT**, **CLK**, and **LAT**.

- To match the example, **CLK** goes to to Digital 2
- **DAT** to Digital 3,
- **LAT** to Digital 4

Once we have the example sketch running you can of course change these to anything you'd like

- Connect **5V** and **GND** to the 5v and Ground Arduino power pins. If you are using a 3.3V Arduino, you still need to power the LCD with 5V power! You can use 3.3V logic just fine



Install Adafruit_LiquidCrystal

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https://adafru.it/kZf

https://adafru.it/kZf

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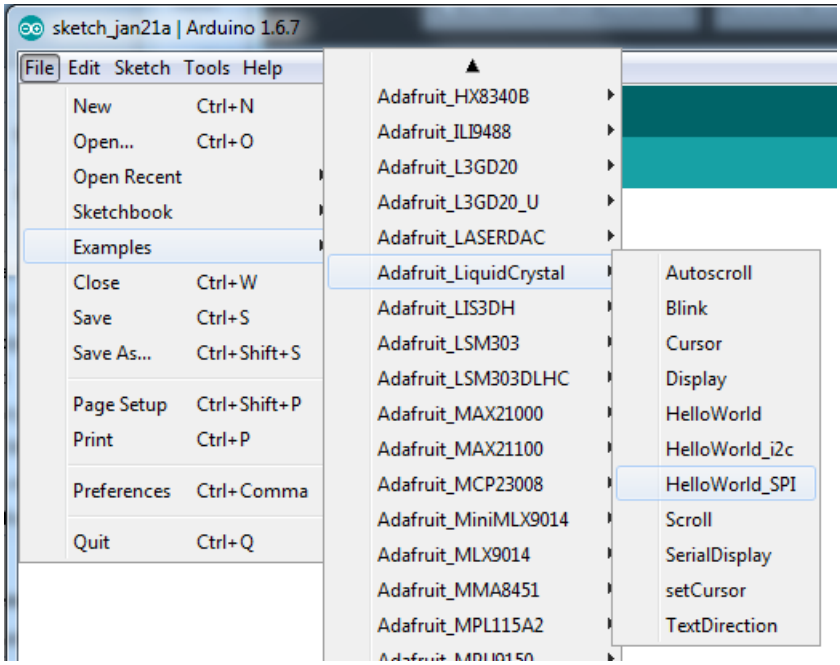
Load Demo

Restart the IDE and load up the **Adafruit_LiquidCrystal->HelloWorld_SPI** demo



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Once you're done, you can remove the blinking LED backlight code:

```
lcd.setBacklight(HIGH);
delay(500);
lcd.setBacklight(LOW);
delay(500);
```

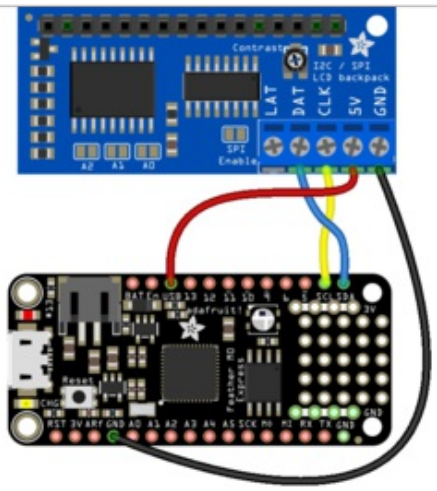
Python & CircuitPython

It's easy to use the character LCD backpack with CircuitPython or Python and the Adafruit CircuitPython CharLCD (https://adafru.it/C47) module. Just like wiring up a LCD in parallel and controlling it from CircuitPython (https://adafru.it/CVQ), you can use the I2C/SPI backpack to also control a LCD from CircuitPython or Python. The same Adafruit CircuitPython CharLCD (https://adafru.it/C47) module allows you to easily write Python code that controls a character LCD (remember only the single color backlight displays are supported by the backpack!).

CircuitPython Microcontroller Wiring

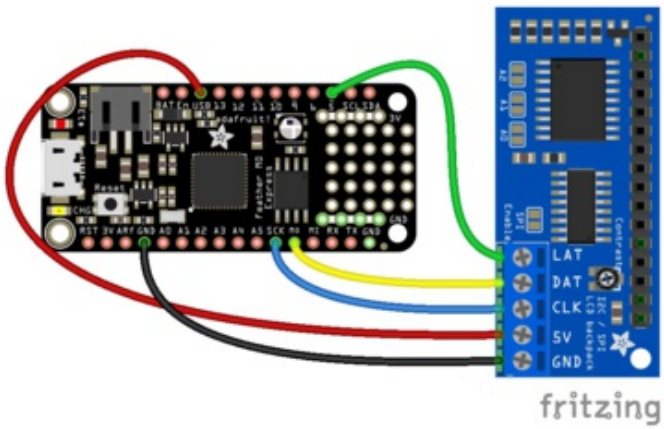
First wire up a character LCD backpack to your board exactly as shown on the previous pages for Arduino using the backpack's I2C or SPI configuration.

Here's an example of wiring a Feather M0 to the backpack with an I2C connection (the recommended wiring):



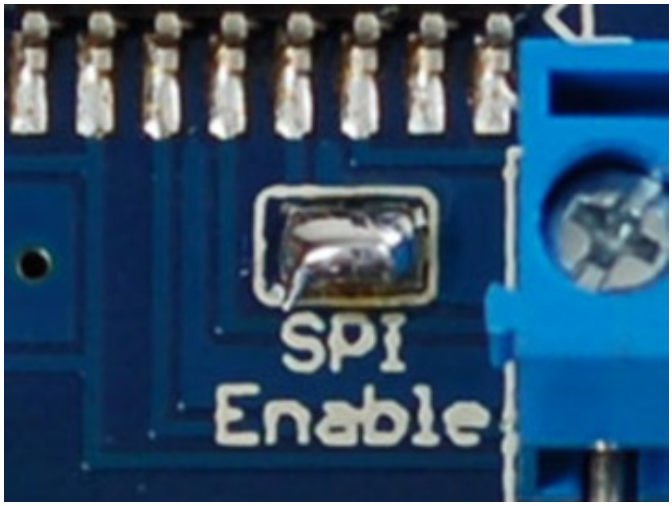
- **Board VUSB** to **backpack 5V** (remember using the VUSB output on a Feather means it **must** be connected to a 5V USB power source like your computer or a battery pack! You can alternatively use the 3.3V output of the Feather but it might not be enough to power the LCD.)
- **Board GND** to **backpack GND.**
- **Board SCL** to **backpack CLK.**
- **Board SDA** to **backpack DAT.**

Or you can wire the LCD backpack to your board using the SPI interface. **Remember you must also solder closed the SPI Enable bridge on the backpack!** Here's an example of wiring a Feather M0 to the backpack with a hardware SPI connection:



- **Board VUSB** to **backpack 5V** (remember using the VUSB output on a Feather means it **must** be connected to a 5V USB power source like your computer or a battery pack! You can alternatively use the 3.3V output of the Feather but it might not be enough to power the LCD.)
- **Board GND** to **backpack GND.**
- **Board SCK** to **backpack CLK.**
- **Board MOSI** to **backpack DAT.**
- **Board D5** to **backpack LAT.**

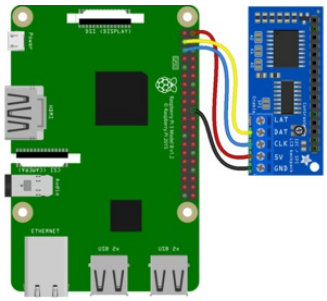
Don't forget to solder closed the SPI jumper on the board if using the SPI wiring!



Python Computer Wiring

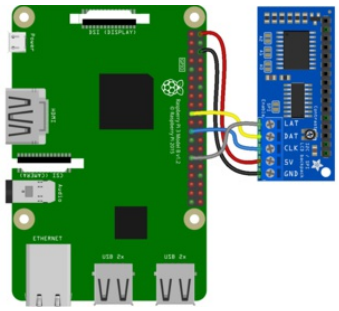
Since there's *dozens* of Linux computers/boards you can use we will show wiring for Raspberry Pi. For other platforms, please visit the guide for CircuitPython on Linux to see whether your platform is supported (https://adafru.it/BSN).

Here's the Raspberry Pi wired to the backpack using I2C:



- **Pi 5V** to **backpack 5V**
- **Pi GND** to **backpack GND.**
- **Pi SCL** to **backpack CLK.**
- **Pi SDA** to **backpack DAT.**

Here's the Raspberry Pi wired to the backpack using SPI:



- **Pi 5V** to **backpack 5V**
- **Pi GND** to **backpack GND.**
- **Pi SCK** to **backpack CLK.**
- **Pi MOSI** to **backpack DAT.**
- **Pi GPIO5** to **backpack LAT.**

CircuitPython Installation of CharLCD Library

You'll need to install the Adafruit CircuitPython CharLCD (https://adafru.it/C47) library on your CircuitPython board.

First make sure you are running the latest version of Adafruit CircuitPython (https://adafru.it/Amd) for your board.

Next you'll need to install the necessary libraries to use the hardware--carefully follow the steps to find and install these libraries from Adafruit's CircuitPython library bundle (https://adafru.it/uap). Our CircuitPython starter guide has a great page on how to install the library bundle (https://adafru.it/ABU).

For non-express boards like the Trinket M0 or Gemma M0, you'll need to manually install the necessary libraries from the bundle:

- **adafruit_character_lcd**
- **adafruit_mcp230xx**
- **adafruit_74hc595**
- **adafruit_bus_device**

Before continuing make sure your board's lib folder or root filesystem has the **adafruit_character_lcd, adafruit_mcp230xx, adafruit_74hc595** and **adafruit_bus_device** files and folders copied over.

Next connect to the board's serial REPL (https://adafru.it/Awz) so you are at the CircuitPython >>> prompt.

Python Installation of CharLCD Library

You'll need to install the Adafruit_Blinka library that provides the CircuitPython support in Python. This may also require enabling I2C on your platform and verifying you are running Python 3. Since each platform is a little different, and Linux changes often, please visit the CircuitPython on Linux guide to get your computer ready (https://adafru.it/BSN)!

Once that's done, from your command line run the following command:

- `sudo pip3 install adafruit-circuitpython-charlcd`

If your default Python is version 3 you may need to run 'pip' instead. Just make sure you aren't trying to use CircuitPython on Python 2.x, it isn't supported!

Python & CircuitPython Usage

To demonstrate the usage of the character LCD we'll initialize it and write text using Python code.

I2C Initialization

For an I2C backpack run the following code to import necessary modules, initialize the I2C bus, and create an instance of the character LCD class:

```
import board
import busio
import adafruit_character_lcd.character_lcd_i2c as character_lcd
i2c = busio.I2C(board.SCL, board.SDA)
cols = 16
rows = 2
lcd = character_lcd.Character_LCD_I2C(i2c, cols, rows)
```

Also notice you need to specify the number of columns and rows for your character LCD. The **cols** and **rows** variables above are setting these values for a 16x2 character LCD. Make sure to set the right value for your LCD!

SPI Initialization

For a SPI backpack as wired above run the following code instead (again be sure to set the right **cols** and **rows** for your display!):

```
import board
import busio
import digitalio
import adafruit_character_lcd.character_lcd_spi as character_lcd
spi = busio.SPI(board.SCK, MOSI=board.MOSI)
latch = digitalio.DigitalInOut(board.D5)
cols = 16
rows = 2
lcd = character_lcd.Character_LCD_SPI(spi, latch, cols, rows)
```

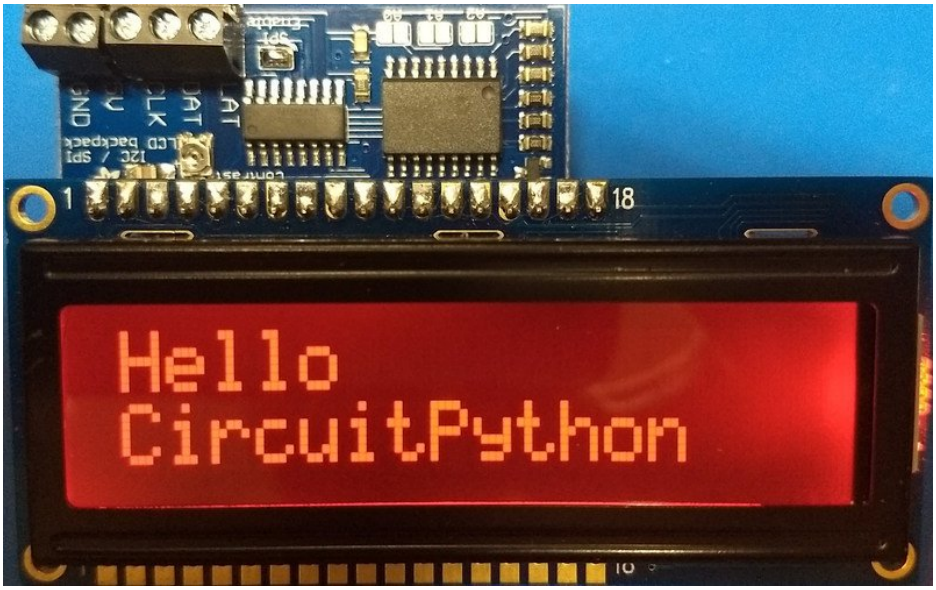
The only big difference with a SPI connection is that you must also import the **digitalio** module and pass in a **DigitalInOut** pin for the latch line. Notice board pin **D5** is used for this wiring--be sure to change the pin if your wiring is different.

Backpack Usage

Now you're ready to start writing text and characters on the display! The usage of the LCD class is **exactly the same** as shown in the parallel LCD wiring guide (https://adafru.it/CVQ). Be sure to check out that guide (https://adafru.it/CVQ) for a complete discussion of LCD usage.

As a quick test though you can run the following code to use the `message` property to write text to the display:

```
lcd.message = "Hello\nCircuitPython!"
```



See the parallel LCD guide for more functions you can call to control the LCD! (https://adafru.it/CVQ)

That's all there is to using the I2C/SPI backpack with CircuitPython!

Full Example Code

As a complete example of I2C usage, see the charlcd_I2C_simpletest.py (https://adafru.it/CbT) example in the character LCD library. Save this as **code.py** on your board and it will run a small demo of LCD functions.

```
"""Simple test for 16x2 character lcd connected to an MCP23008 I2C LCD backpack."""
import time
import board
import busio
import adafruit_character_lcd.character_lcd_i2c as character_lcd

# Modify this if you have a different sized Character LCD
lcd_columns = 16
lcd_rows = 2

# Initialise I2C bus.
i2c = busio.I2C(board.SCL, board.SDA)

# Initialise the lcd class
lcd = character_lcd.Character_LCD_I2C(i2c, lcd_columns, lcd_rows)

# Turn backlight on
lcd.backlight = True
# Print a two line message
lcd.message = "Hello\nCircuitPython"
# Wait 5s
time.sleep(5)
lcd.clear()
# Print two line message right to left
lcd.text_direction = lcd.RIGHT_TO_LEFT
lcd.message = "Hello\nCircuitPython"
# Wait 5s
time.sleep(5)
# Return text direction to left to right
lcd.text_direction = lcd.LEFT_TO_RIGHT
# Display cursor
lcd.clear()
lcd.cursor = True
lcd.message = "Cursor! "
# Wait 5s
time.sleep(5)
# Display blinking cursor
lcd.clear()
lcd.blink = True
lcd.message = "Blinky Cursor!"
# Wait 5s
time.sleep(5)
lcd.blink = False
lcd.clear()
# Create message to scroll
scroll_msg = '<-- Scroll'
lcd.message = scroll_msg
# Scroll message to the left
for i in range(len(scroll_msg)):
    time.sleep(0.5)
    lcd.move_left()
lcd.clear()
lcd.message = "Going to sleep\nCya later!"
time.sleep(5)
# Turn backlight off
lcd.backlight = False
time.sleep(2)
```

And a complete example of SPI usage is in the charlcd_SPI_simpletest.py (https://adafru.it/CbU) example in the library. Save this as **code.py** on your board and it will run a small demo of LCD functions.

```
"""Simple test for 16x2 character LCD connected to 74HC595 SPI LCD backpack."""
import time
import board
import busio
import digitalio
import adafruit_character_lcd.character_lcd_spi as character_lcd

# Modify this if you have a different sized character LCD
lcd_columns = 16
lcd_rows = 2

# Backpack connection configuration:
clk = board.SCK  # Pin connected to backpack CLK.
data = board.MOSI  # Pin connected to backpack DAT/data.
latch = board.D5  # Pin connected to backpack LAT/latch.

# Initialise SPI bus.
spi = busio.SPI(clk, MOSI=data)

# Initialise the LCD class
latch = digitalio.DigitalInOut(latch)
lcd = character_lcd.Character_LCD_SPI(spi, latch, lcd_columns, lcd_rows)

# Turn backlight on
lcd.backlight = True
# Print a two line message
lcd.message = "Hello\nCircuitPython"
# Wait 5s
time.sleep(5)
lcd.clear()
# Print two line message right to left
lcd.text_direction = lcd.RIGHT_TO_LEFT
lcd.message = "Hello\nCircuitPython"
# Wait 5s
time.sleep(5)
# Return text direction to left to right
lcd.text_direction = lcd.LEFT_TO_RIGHT
# Display cursor
lcd.clear()
lcd.cursor = True
lcd.message = "Cursor! "
# Wait 5s
time.sleep(5)
# Display blinking cursor
lcd.clear()
lcd.blink = True
lcd.message = "Blinky Cursor!"
# Wait 5s
time.sleep(5)
lcd.blink = False
lcd.clear()
# Create message to scroll
scroll_msg = '<-- Scroll'
lcd.message = scroll_msg
# Scroll message to the left
for i in range(len(scroll_msg)):
```

```
for i in range(len(scroll_msg)):
    time.sleep(0.5)
    lcd.move_left()
lcd.clear()
lcd.message = "Going to sleep\nCya later!"
# Turn backlight off
lcd.backlight = False
time.sleep(2)
```

Python Docs

Python Docs (https://adafru.it/C49)

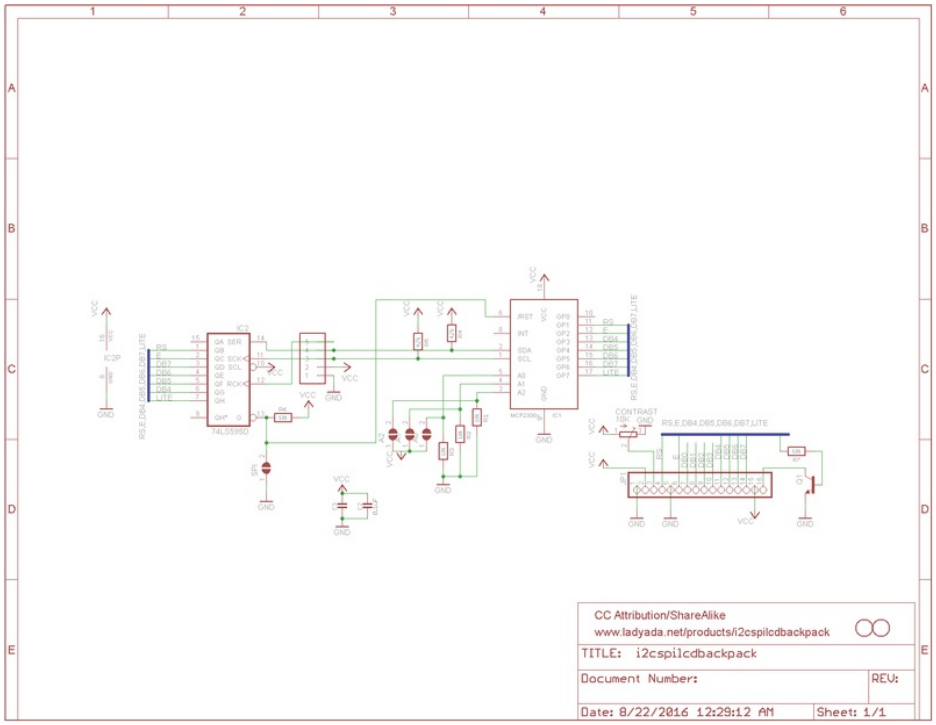
Downloads

Hardware files

Eagle CAD format schematic and board layout file (as well as a PNG of the schematic) are all available in the GitHub repository (https://adafru.it/aP2)

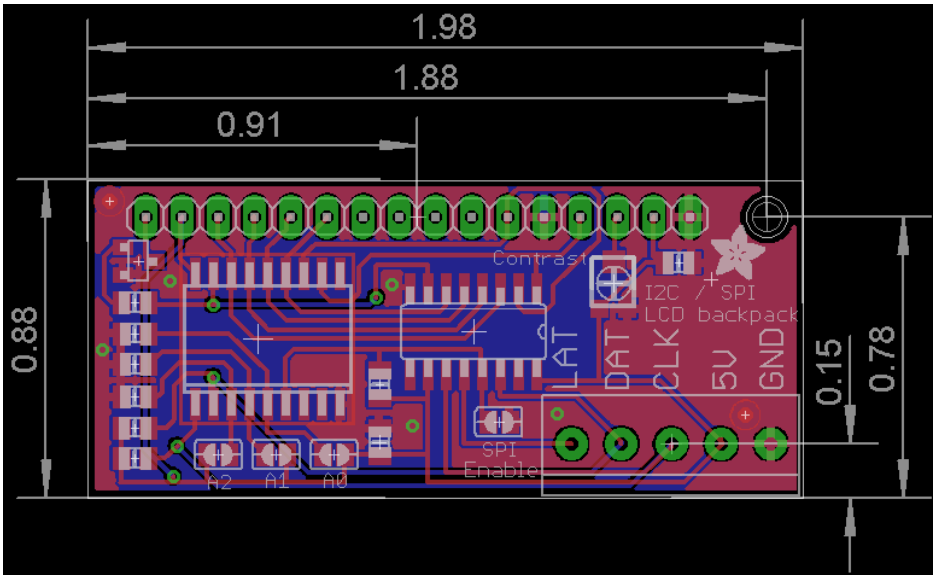
Fritzing object available in the Adafruit Fritzing Library (https://adafru.it/aP3)

Schematic



Fabrication Print

Dims in inches


1.98
1.88
0.91
0.88
0.15
0.78
Contrast
I2C / SPI
LCD backpack
LAT
DAT
CLK
5V
GND
SPI
Enable
A2
A1
A0