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## Adafruit 3.5" 320x480 Color TFT Touchscreen Breakout

Created by lady ada

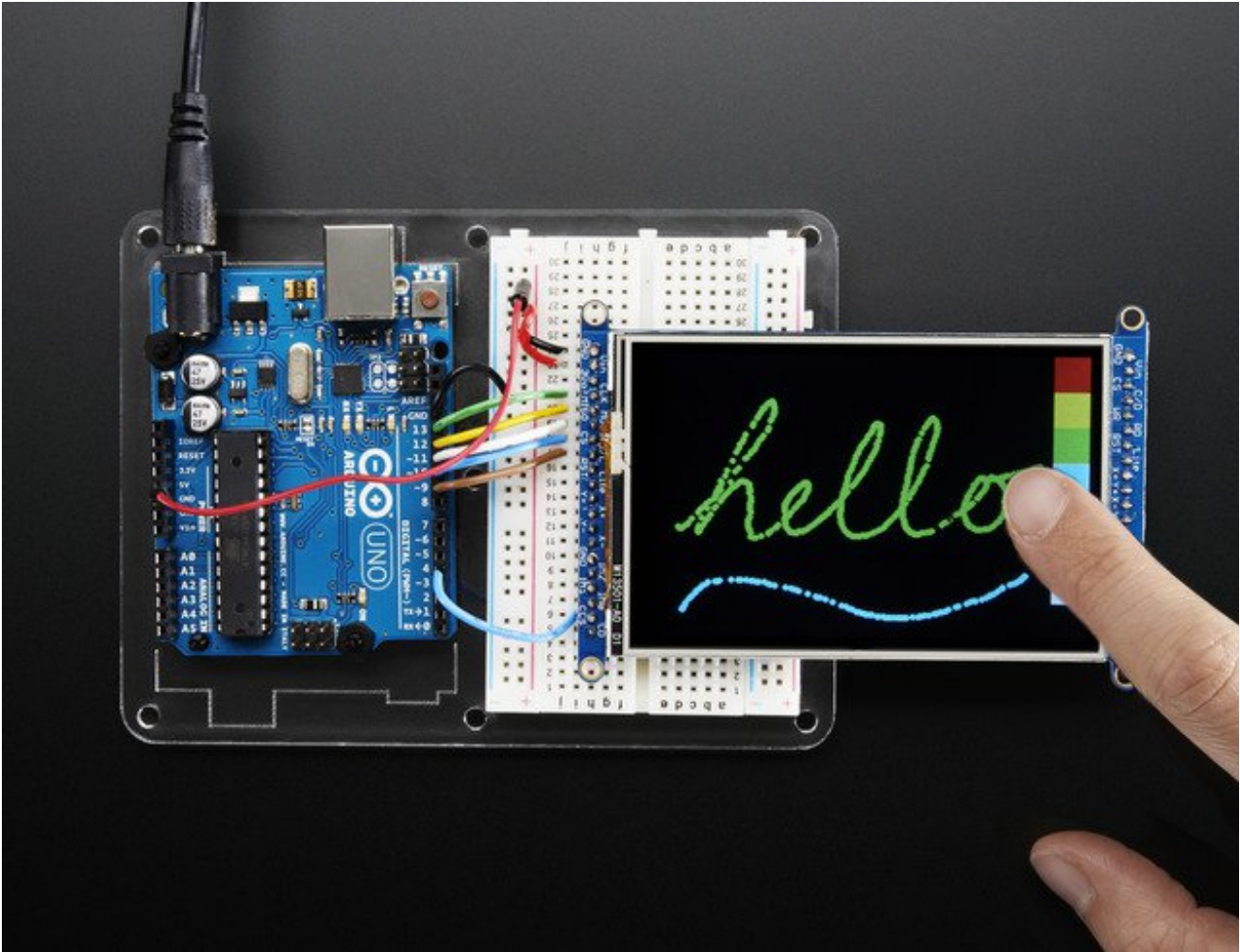


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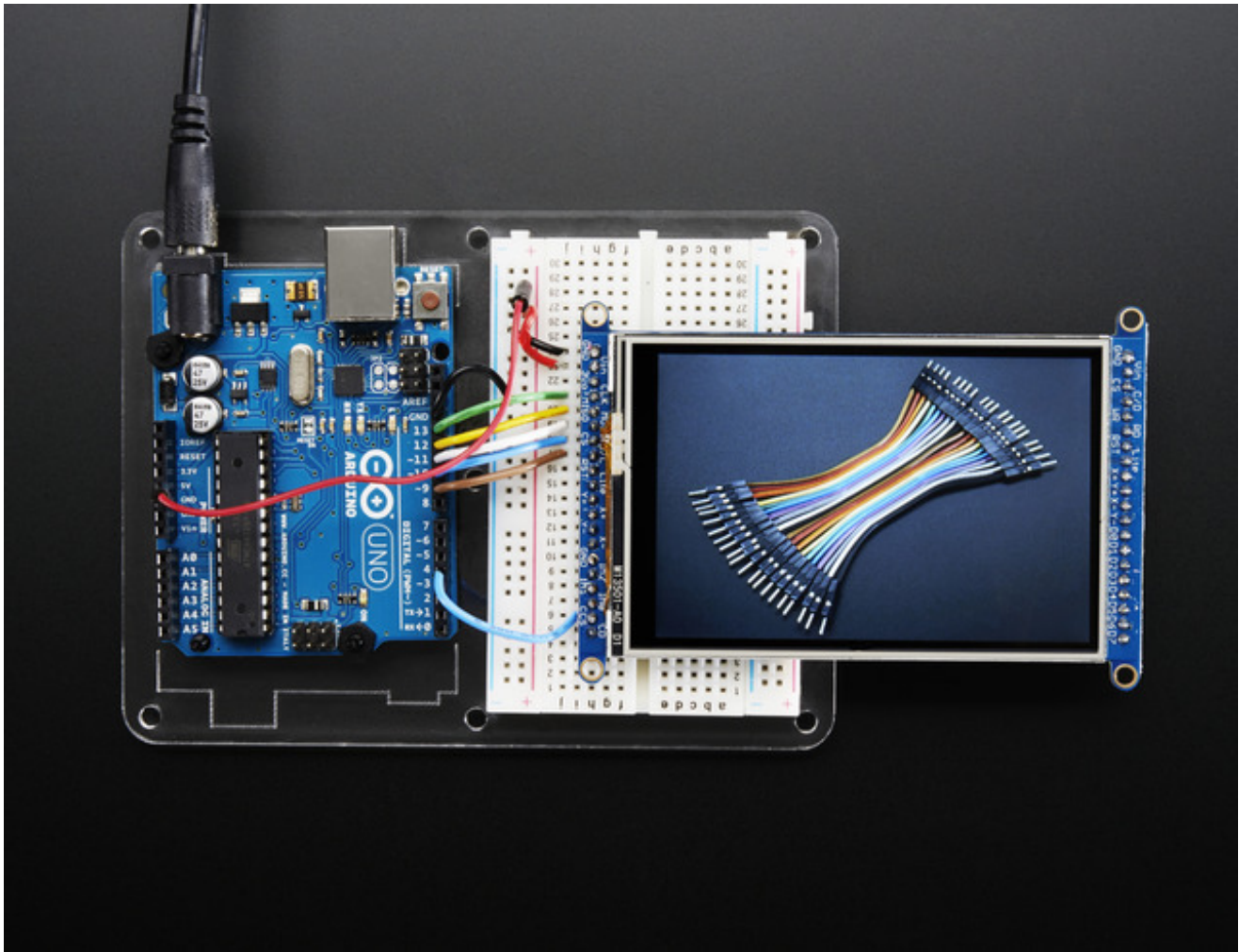
# Guide Contents

Guide Contents	2
Overview	3
Pinouts	7
SPI Mode	7
8-Bit Mode	9
Wiring & Test	11
Assembling Header	11
Prepare the header strip:	12
Add the breakout board:	13
Add the breakout board:	14
8-Bit Wiring & Test	16
8-Bit Wiring	16
Part 1 - Power & backlight test	16
Part 2 - Data Bus Lines	18
8-Bit Library Install	22
Prepare TFTLCD Library	23
SPI Wiring & Test	29
SPI Mode Jumpers	29
Wiring	32
Install Adafruit HX8357 TFT Library	33
Bitmaps (SPI Mode)	36
Adafruit GFX library	39
Touchscreen	41
Download Library	42
Touchscreen Paint (SPI mode)	42
Touchscreen Paint (8-Bit mode)	44
Downloads	46
Datasheets & Files	46
Schematic and PCB Print	46

# Overview

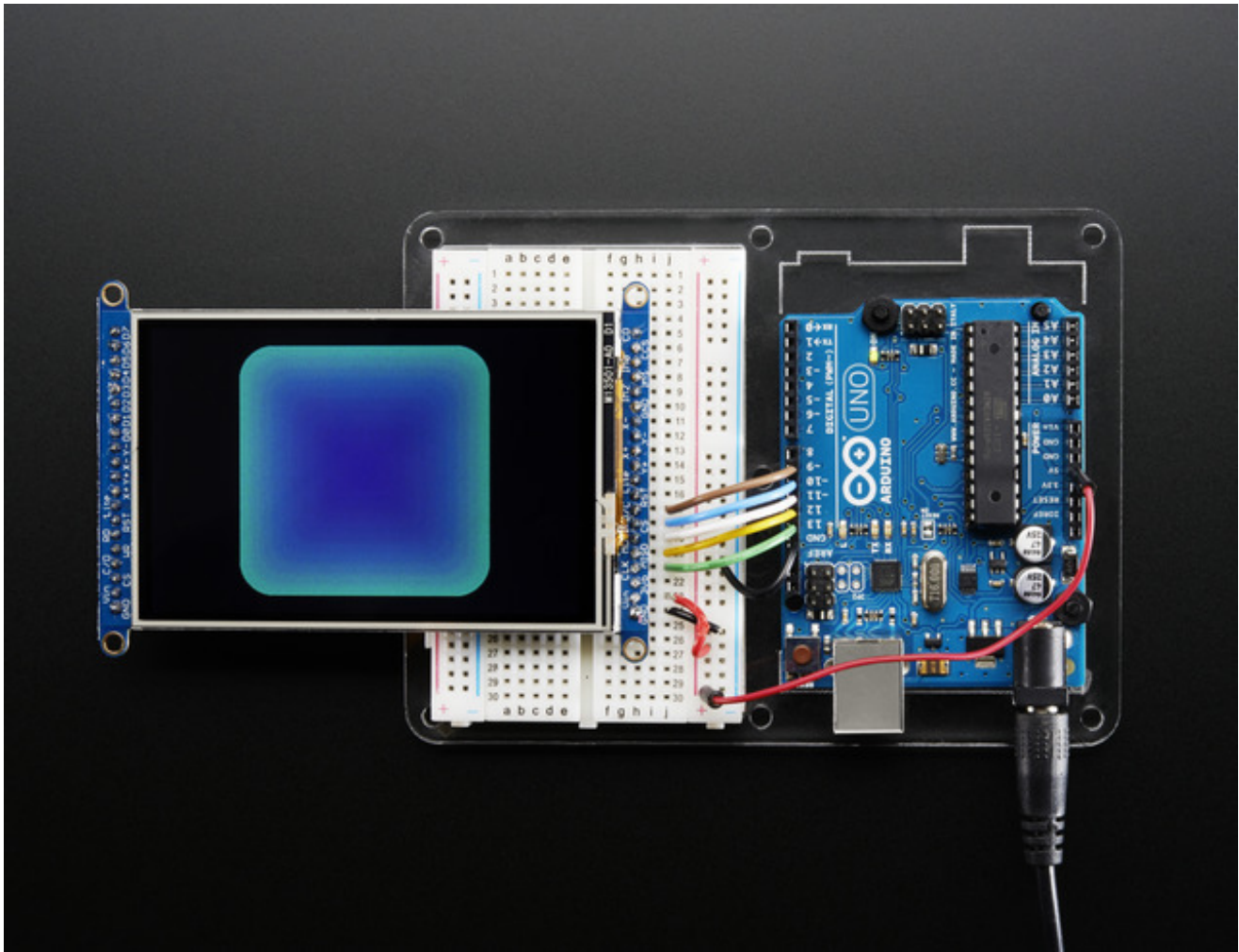


Add some jazz & pizzazz to your project with a color touchscreen LCD. This TFT display is big (3.5" diagonal) bright (6 white-LED backlight) and colorful! 480x320 pixels with individual RGB pixel control, this has way more resolution than a black and white 128x64 display, and double our 2.8" TFT. As a bonus, this display has a resistive touchscreen attached to it already, so you can detect finger presses anywhere on the screen.

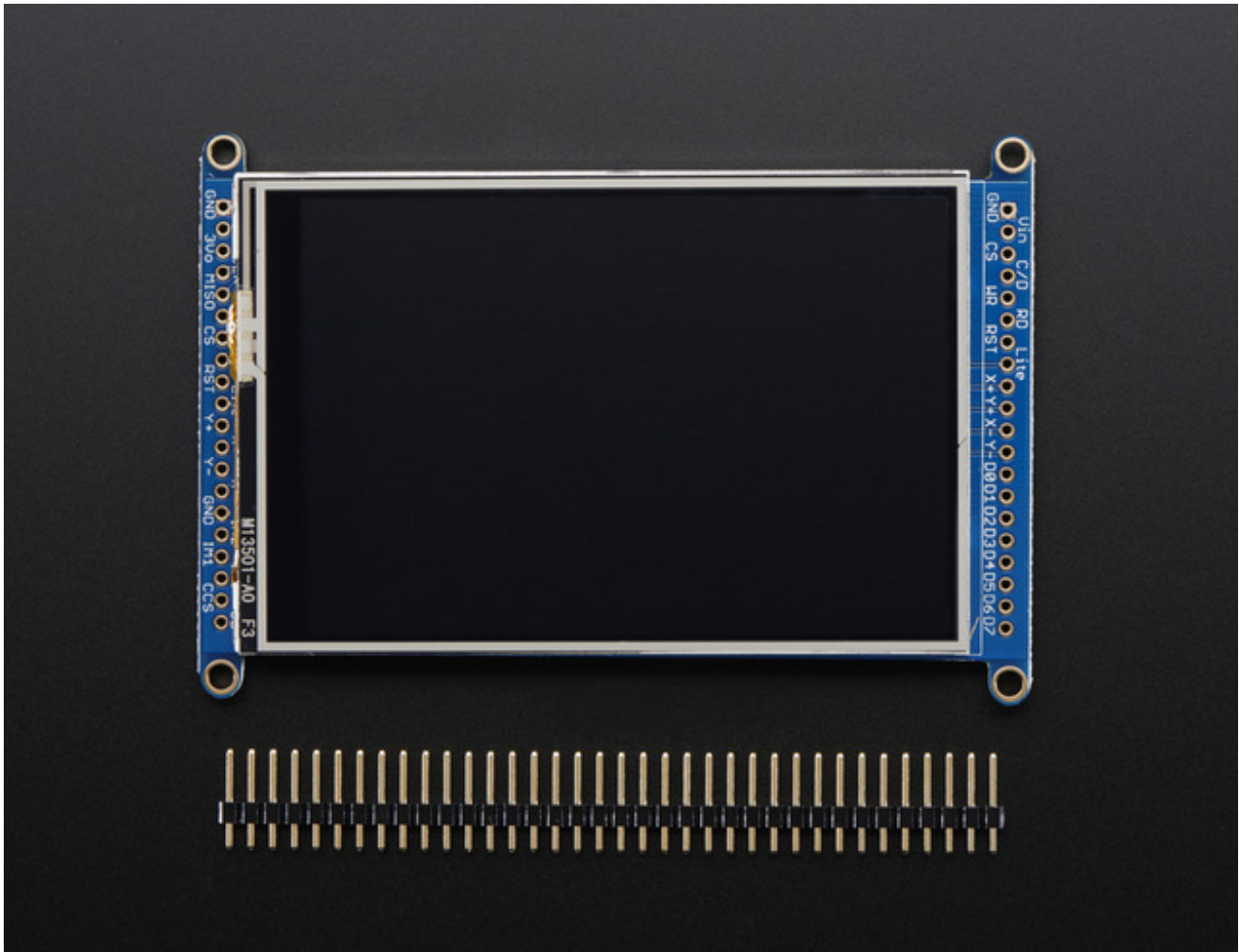


This display has a controller built into it with RAM buffering, so that almost no work is done by the microcontroller. **The display can be used in two modes: 8-bit or SPI.** For 8-bit mode, you'll need 8 digital data lines and 4 or 5 digital control lines to read and write to the display (12 lines total). SPI mode requires only 5 pins total (SPI data in, data out, clock, select, and d/c) but is slower than 8-bit mode. In addition, 4 pins are required for the touch screen (2 digital, 2 analog) or [you can purchase and use our resistive touchscreen controller \(not included\) to use I2C or SPI \(http://adafruit.it/1571\)](http://adafruit.it/1571).

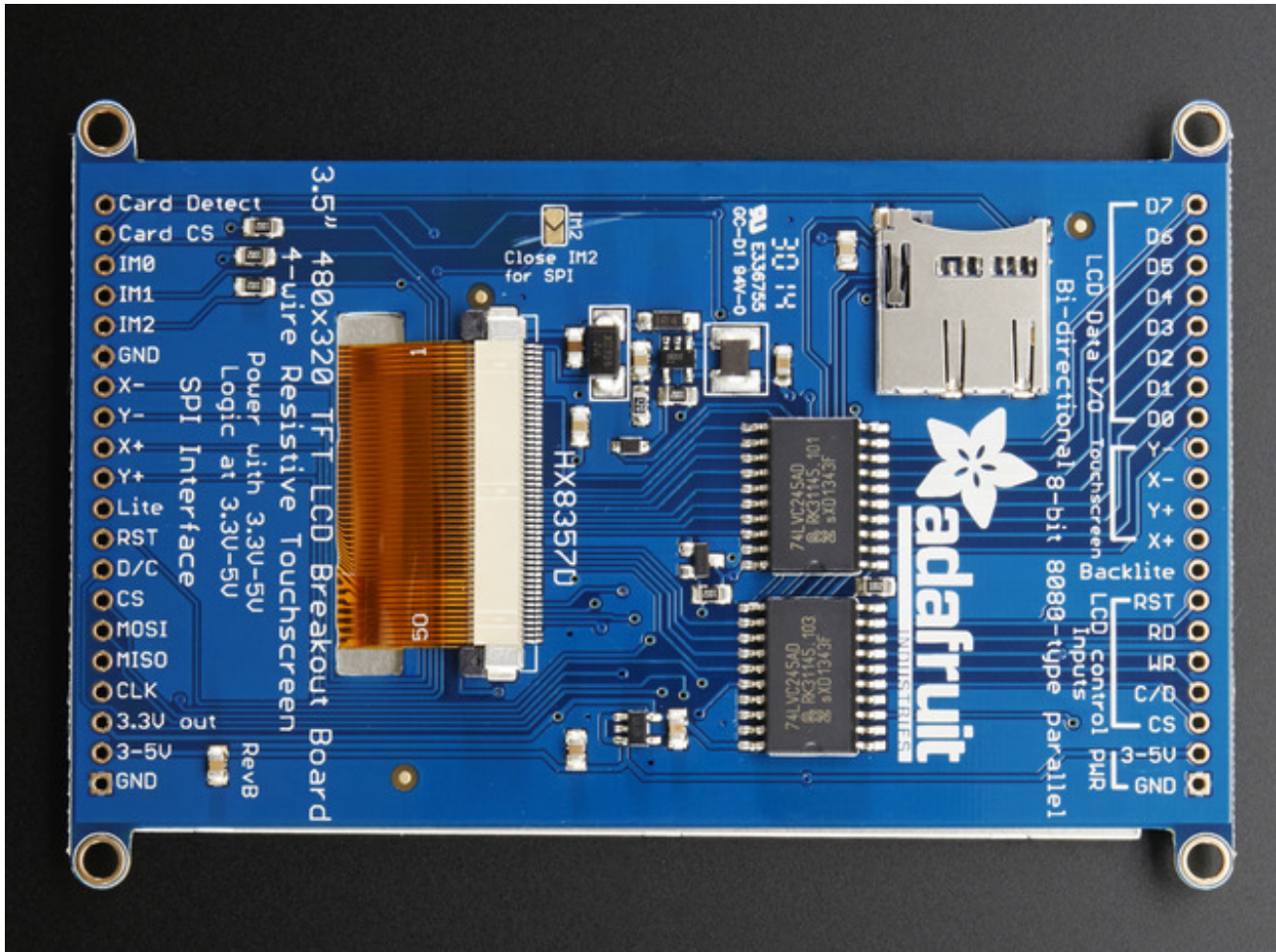




Of course, we wouldn't just leave you with a datasheet and a "good luck!". For 8-bit interface fans [we've written a full open source graphics library that can draw pixels, lines, rectangles, circles, text, and more](http://adafruit.it/aHk) (<http://adafruit.it/aHk>). For [SPI users, we have a library as well](http://adafruit.it/dQW) (<http://adafruit.it/dQW>), its separate from the 8-bit library since both versions are heavily optimized. We [also have a touch screen library that detects x, y and z \(pressure\)](http://adafruit.it/aT1) (<http://adafruit.it/aT1>) and example code to demonstrate all of it.



# Pinouts



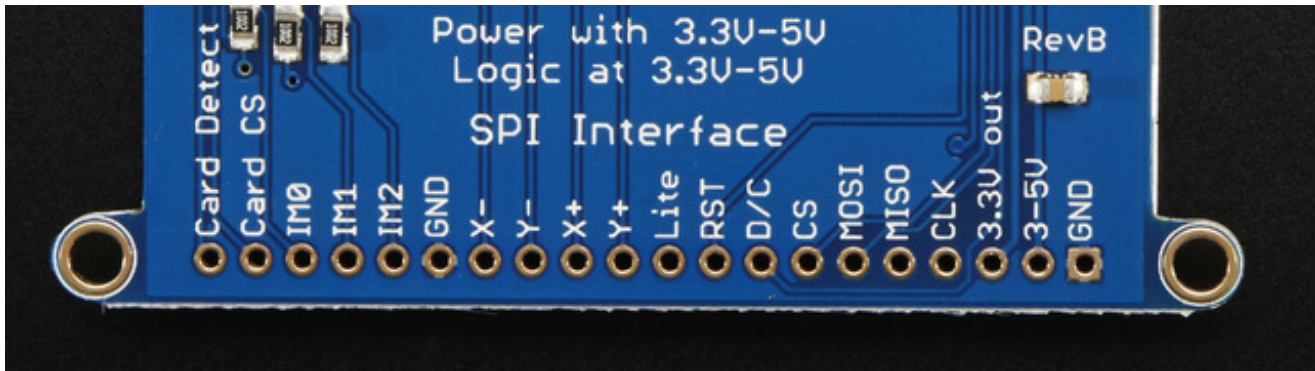
The 3.5" TFT display on this breakout supports many different modes - so many that the display itself has 50 pins. However, we think most people really only use 2 different modes, either "SPI" mode or 8-bit mode. Each 'side' of the display has all the pins required for that mode. You can switch between modes, by rewiring the display, but it cannot be used in two modes at the same time!

All logic pins, both 8-bit and SPI sides, are 3-5V logic level compatible, the 74LVX245 chips on the back perform fast level shifting so you can use either kind of logic levels. If there's data output, the levels are at at 3.3V

## SPI Mode



This is what we think will be a popular mode when speed is not of the utmost importance. It doesn't use as many pins (only 4 to draw on the TFT if you skip the MISO pin), is fairly flexible, and easy to port to various microcontrollers. It also allows using a microSD card socket on the same SPI bus. However, its slower than parallel 8-bit mode because you have to send each bit at a time instead of 8-bits at a time. Tradeoffs!



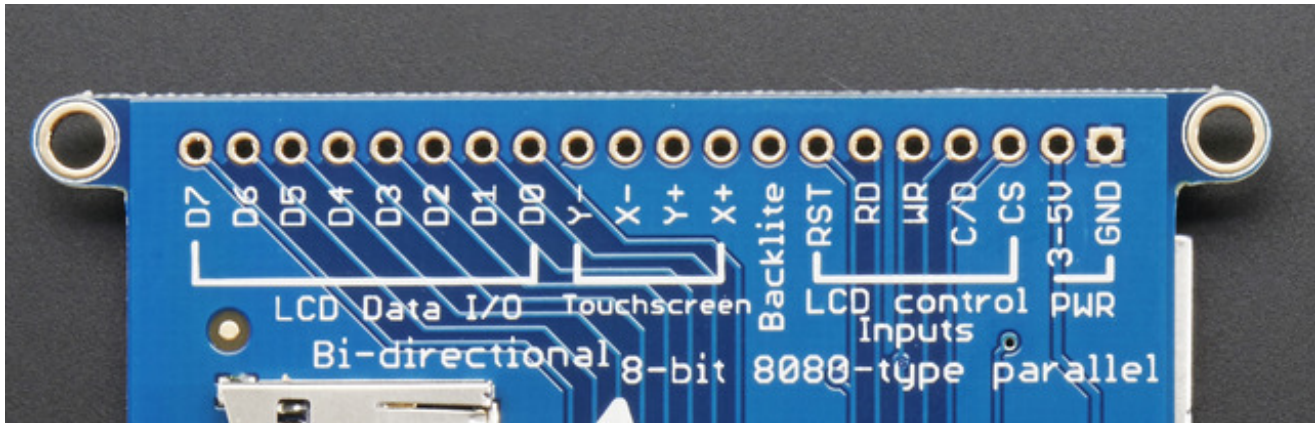
- **GND** - this is the power and signal ground pin
- **3-5V / Vin** - this is the power pin, connect to 3-5VDC - it has reverse polarity protection but try to wire it right!
- **3.3Vout** - this is the 3.3V output from the onboard regulator
- **CLK** - this is the SPI clock input pin
- **MISO** - this is the SPI Master In Slave Out pin, its used for the SD card mostly, and for debugging the TFT display. It isn't necessary for using the TFT display which is write-only
- **MOSI** - this is the SPI Master Out Slave In pin, it is used to send data from the microcontroller to the SD card and/or TFT
- **CS** - this is the TFT SPI chip select pin
- **D/C** - this is the TFT SPI data or command selector pin
- **RST** - this is the TFT reset pin. There's auto-reset circuitry on the breakout so this pin is not required but it can be helpful sometimes to reset the TFT if your setup is not always resetting cleanly. Connect to ground to reset the TFT
- **Lite** - this is the PWM input for the backlight control. It is by default pulled high (backlight on) you can PWM at any frequency or pull down to turn the backlight off
- **Y+ X+ Y- X-** these are the 4 resistive touch screen pads, which can be read with analog pins to determine touch points. They are completely separated from the TFT electrically (the overlay is glued on top)
- **IM2 IM1 IM0** - these are interface control set pins. In general these breakouts aren't used, and instead the onboard jumpers are used to fix the interface to SPI or 8-bit. However, we break these out for advanced use and also for our test procedures
- **Card CS / CCS** - this is the SD card chip select, used if you want to read from the SD card.
- **Card Detect / CD** - this is the SD card detect pin, it floats when a card is inserted,



and tied to ground when the card is not inserted. We don't use this in our code but you can use this as a switch to detect if an SD card is in place without trying to electrically query it. Don't forget to use a pullup on this pin if so!

## 8-Bit Mode

This mode is for when you have lots of pins and want more speed. In this mode we send 8 bits at a time, so it needs way more pins, 12 or so (8 bits plus 4 control)! If your microcontroller



- **GND** - this is the power and signal ground pin
- **3-5V (Vin)**- this is the power pin, connect to 3-5VDC - it has reverse polarity protection but try to wire it right!
- **CS** - this is the TFT 8-bit chip select pin (it is also tied to the SPI mode **CS** pin)
- **C/D** - this is the TFT 8-bit data or command selector pin (it is also tied to the SPI mode **C/D** pin)
- **WR** - this is the TFT 8-bit write strobe pin. It is also connected to the **SPI CLK** pin
- **RD** - this is the TFT 8-bit read strobe pin. You may not need this pin if you don't want to read data from the display
- **RST** - this is the TFT reset pin. There's auto-reset circuitry on the breakout so this pin is not required but it can be helpful sometimes to reset the TFT if your setup is not always resetting cleanly. Connect to ground to reset the TFT
- **Backlite** - this is the PWM input for the backlight control. It is by default pulled high (backlight on) you can PWM at any frequency or pull down to turn the backlight off
- **Y+ X+ Y- X-** these are the 4 resistive touch screen pads, which can be read with analog pins to determine touch points. They are completely separated from the TFT electrically (the overlay is glued on top)
- **D0** thru **D7** - these are the 8 bits of parallel data sent to the TFT in 8-bit mode **D0** is the least-significant-bit and **D7** is the MSB





## Wiring & Test

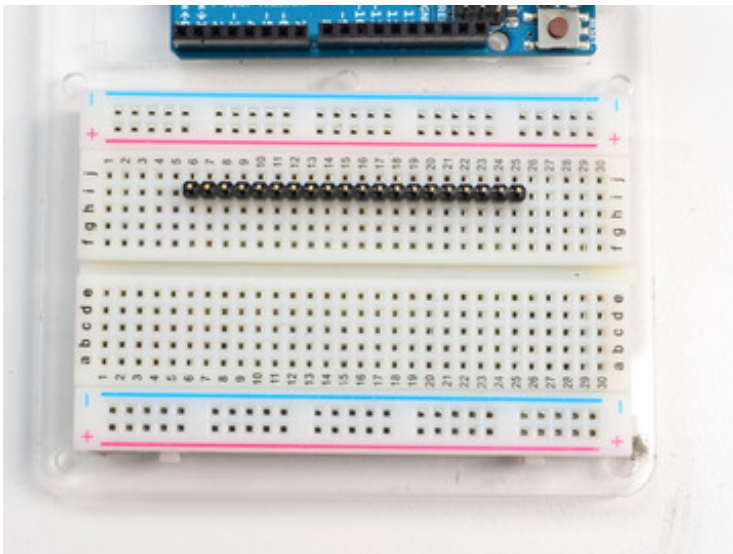
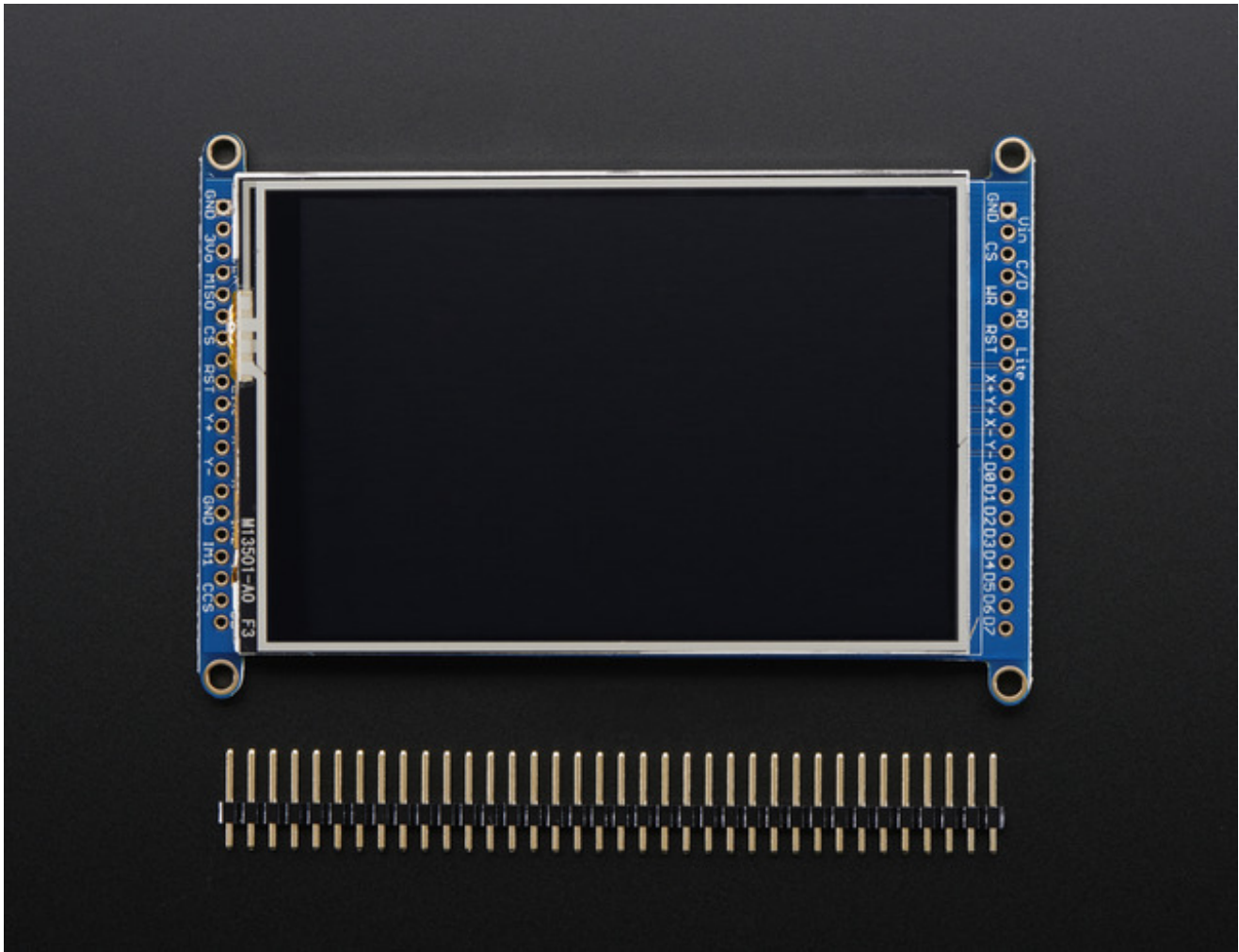
We tried to make this TFT breakout useful for both high-pin microcontrollers that can handle 8-bit data transfer modes as well as low-pincount micros like the Arduino UNO and Leonardo that are OK with SPI.

Essentially, the tradeoff is pins for speed. SPI is about 2-4 times slower than 8-bit mode, but that may not matter for basic graphics!

In addition, SPI mode has the benefit of being able to use the onboard microSD card socket for reading images. We don't have support for this in 8-bit mode so if you want to have an all-in-one image viewer type application, use SPI!

## Assembling Header

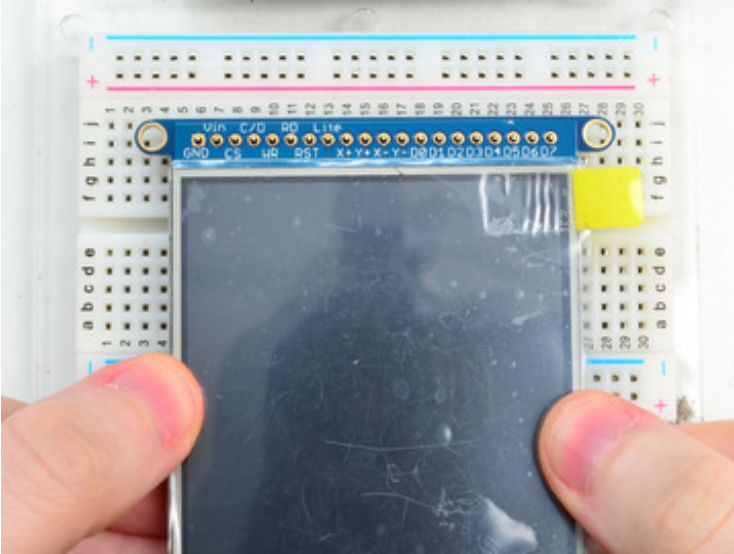
Either way, if you're using a breadboard, you'll need to solder header onto one or two of the sides. The procedure is the same for both sides



## Prepare the header strip:

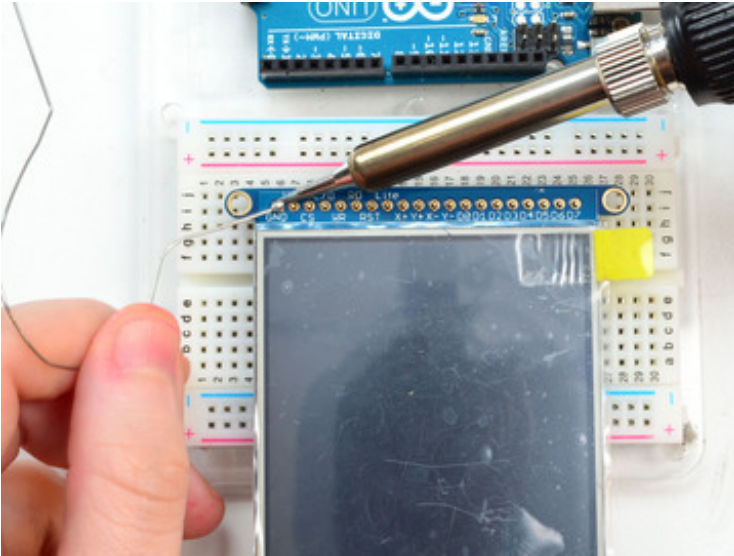
Cut the strip to length if necessary. It will be easier to solder if you insert it into a breadboard - **long pins down**





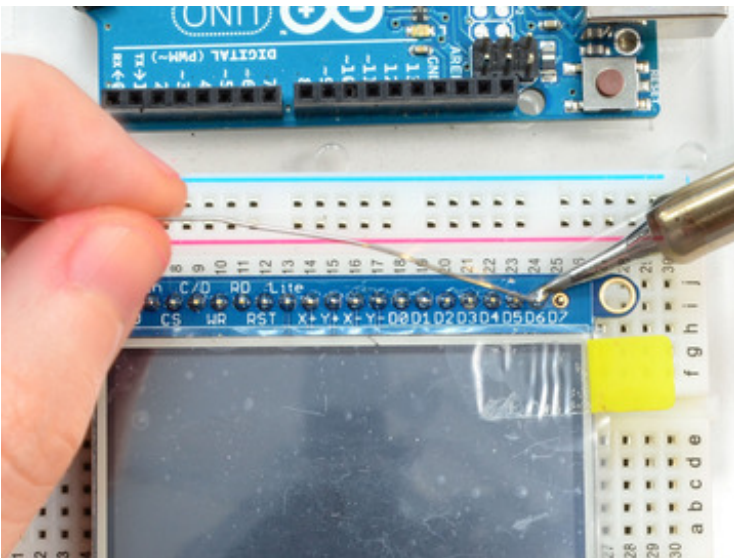
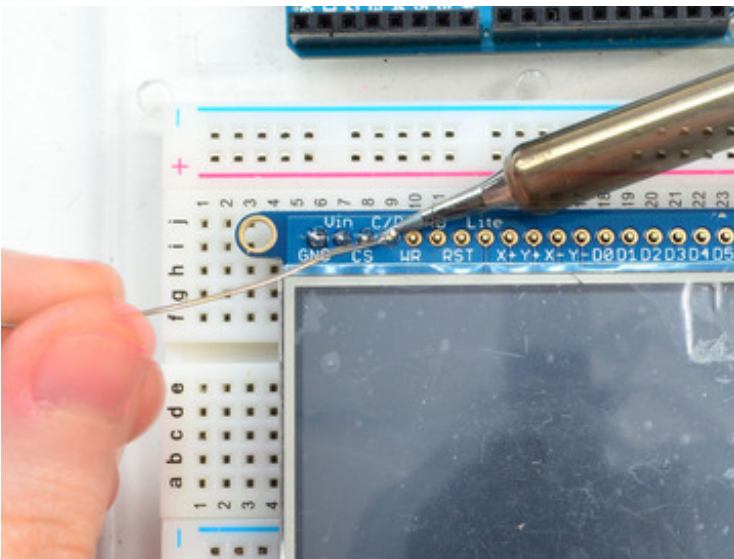
## Add the breakout board:

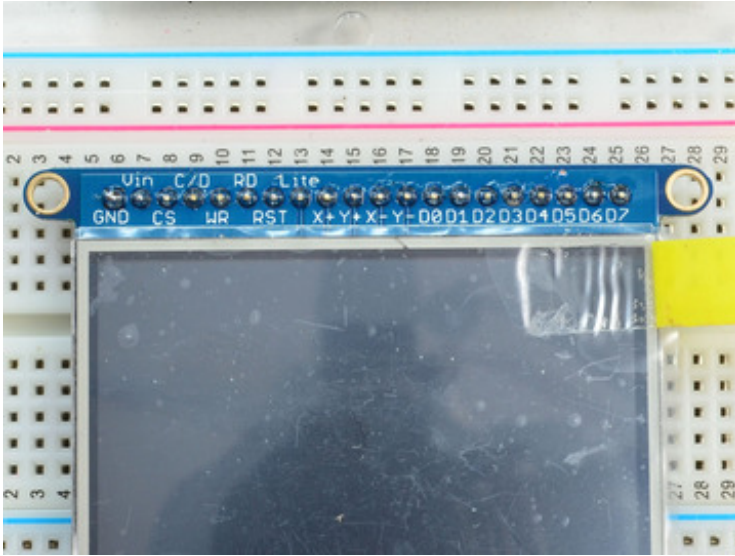
Place the breakout board over the pins so that the short pins poke through the breakout pads



## Add the breakout board:

Place the breakout board over the pins so that the short pins poke through the breakout pads





You're done! Check your solder joints visually and continue onto the next steps

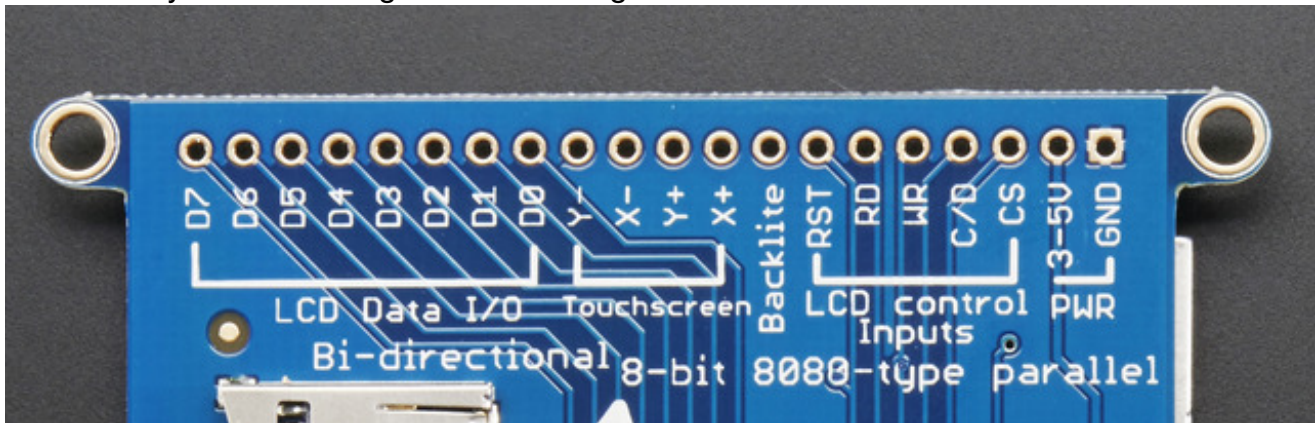
# 8-Bit Wiring & Test

## 8-Bit Wiring

Wiring up the 8-bit mode is kind of a pain, so we really only recommend doing it for UNO (which we show) and Mega (which we describe, and is pretty easy since its 8 pins in a row). Anything else, like a Leonardo or Micro, we strongly recommend going with SPI mode since we don't have an example for that. Any other kind of 'Arduino compatible' that isn't an Uno, try SPI first. The 8-bit mode is hand-tweaked in the **Adafruit\_TFTLCD pin\_magic.h** file. Its really only for advanced users who are totally cool with figuring out bitmasks for various ports & pins.

Really, we'll show how to do the UNO but anything else? go with SPI!

Make sure you're soldering and connecting to the 8-bit side!



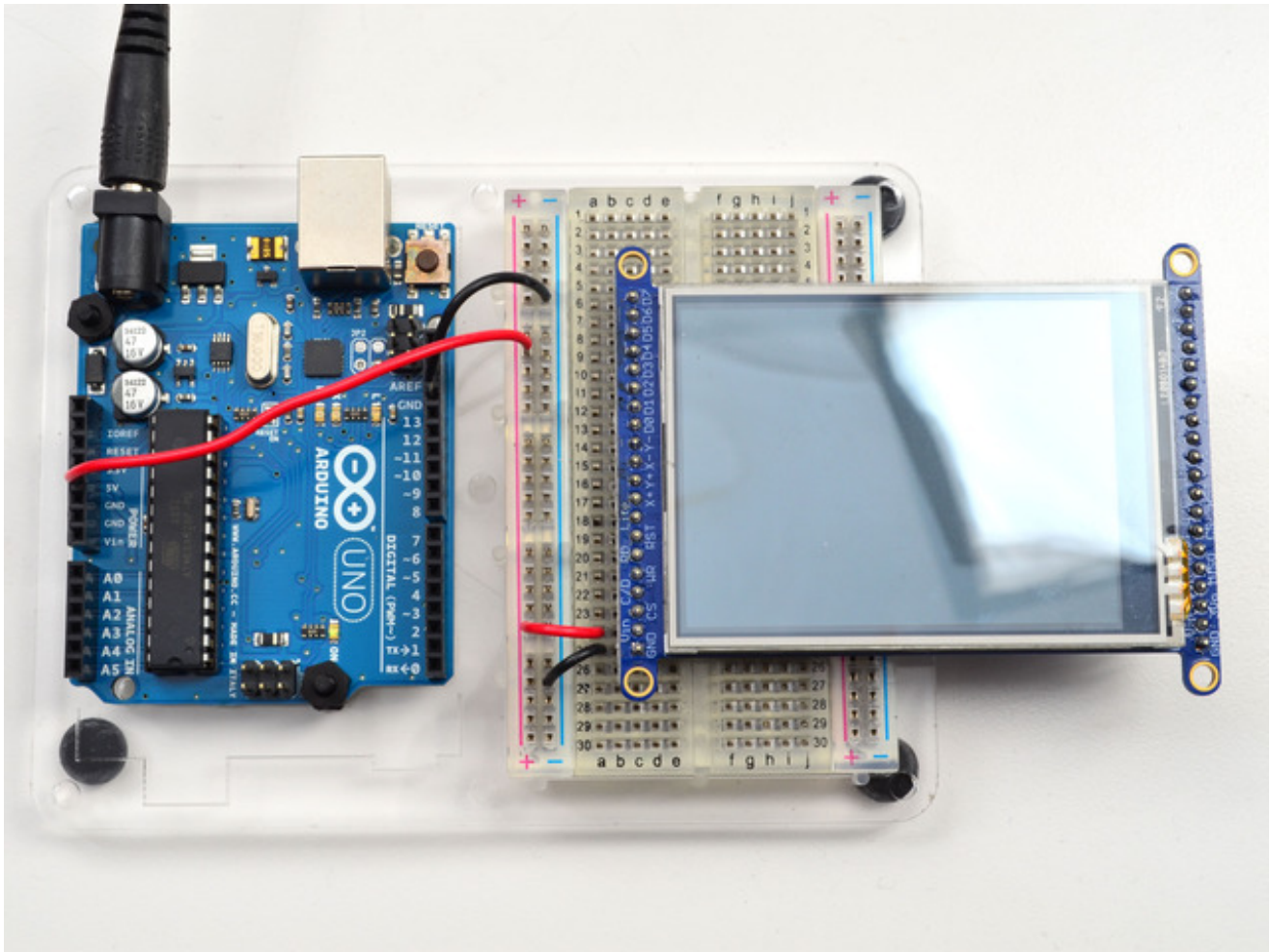
### Part 1 - Power & backlight test

In these images we show using our 2.8" TFT but its the exact same pinout, just a tad smaller!

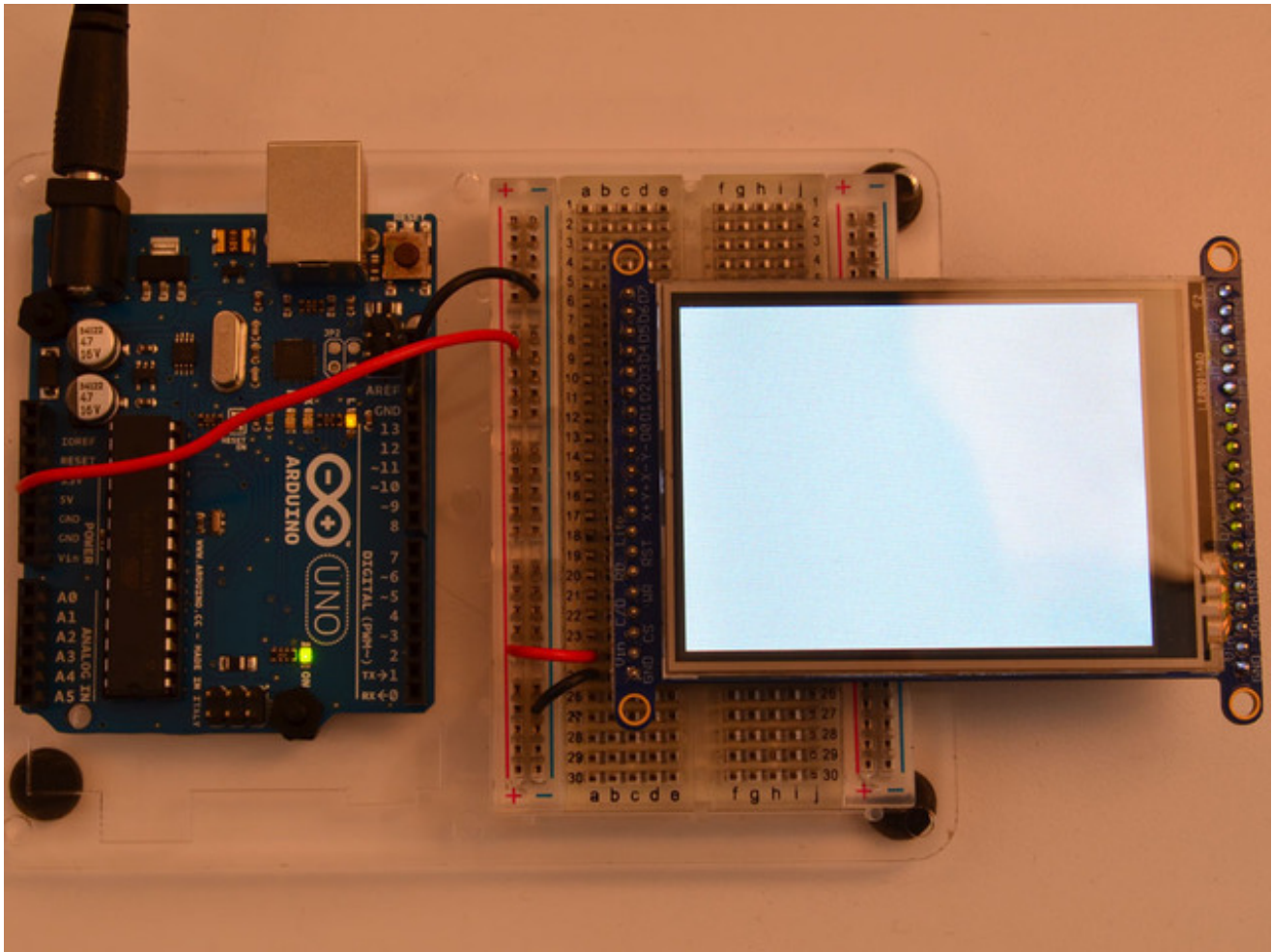
Begin by wiring up the **3-5VDC** and **GND** pins.

Connect the **3-5V** pin to **5V** and **GND** to **GND** on your Arduino. I'm using the breadboard rails but you can also just wire directly.





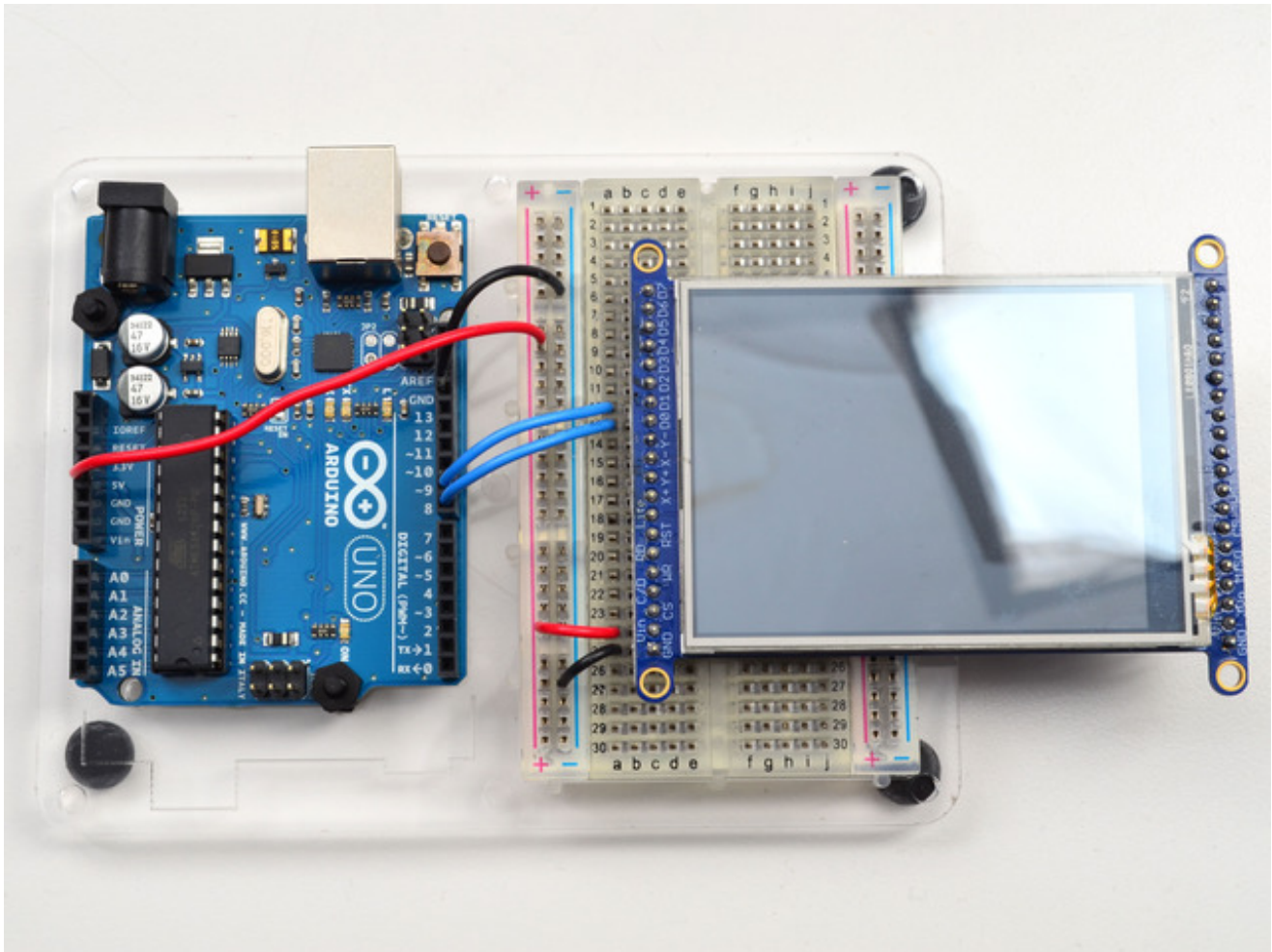
Power it up and you should see the white backlight come on



## Part 2 - Data Bus Lines

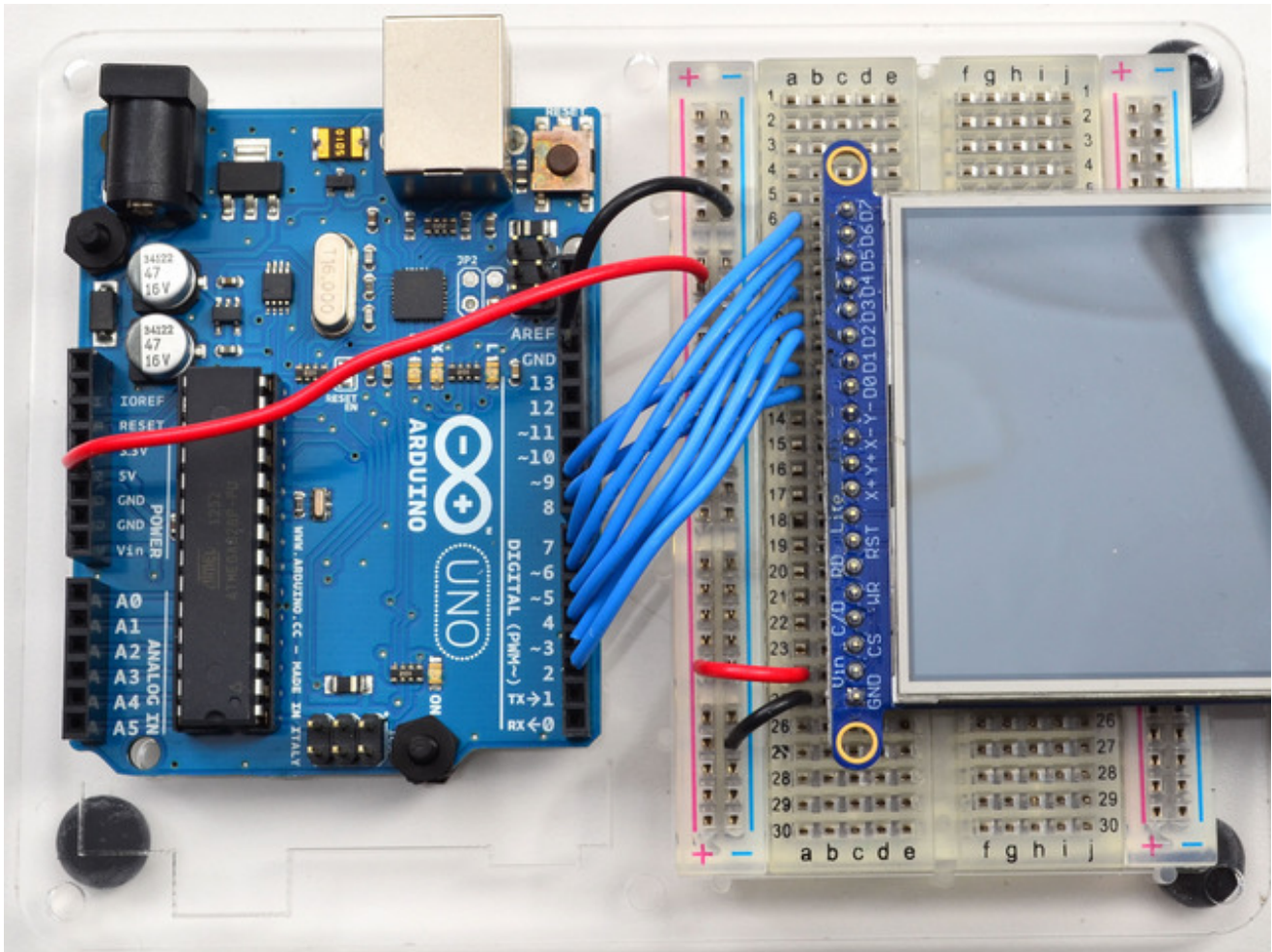
Now that the backlight is working, we can get the TFT LCD working. There are many pins required, and to keep the code running fairly fast, we have 'hardcoded' Arduino digital pins **#2-#9** for the 8 data lines.

**However, they are not in that order!** D0 and D1 go to **digital #8** and **#9**, then D2-D7 connect to **#2** thru **#7**. This is because Arduino pins **#0** and **#1** are used for serial data so we can't use them



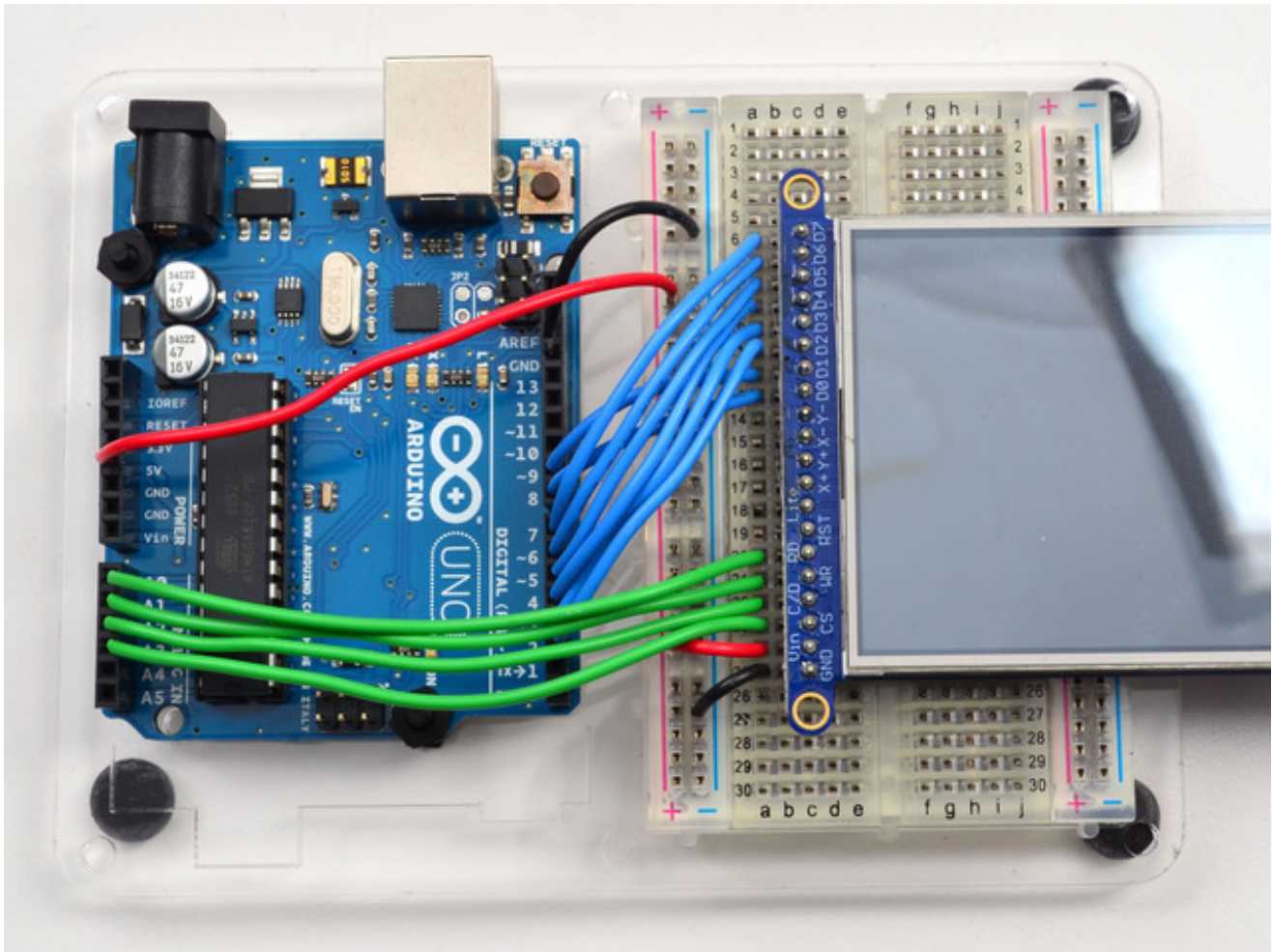
Begin by connecting **D0** and **D1** to digital **#8** and **9** respectively as seen above. If you're using a Mega, connect the TFT Data Pins **D0-D1** to Mega pins **#22-23**, in that order. Those Mega pins are on the 'double' header.





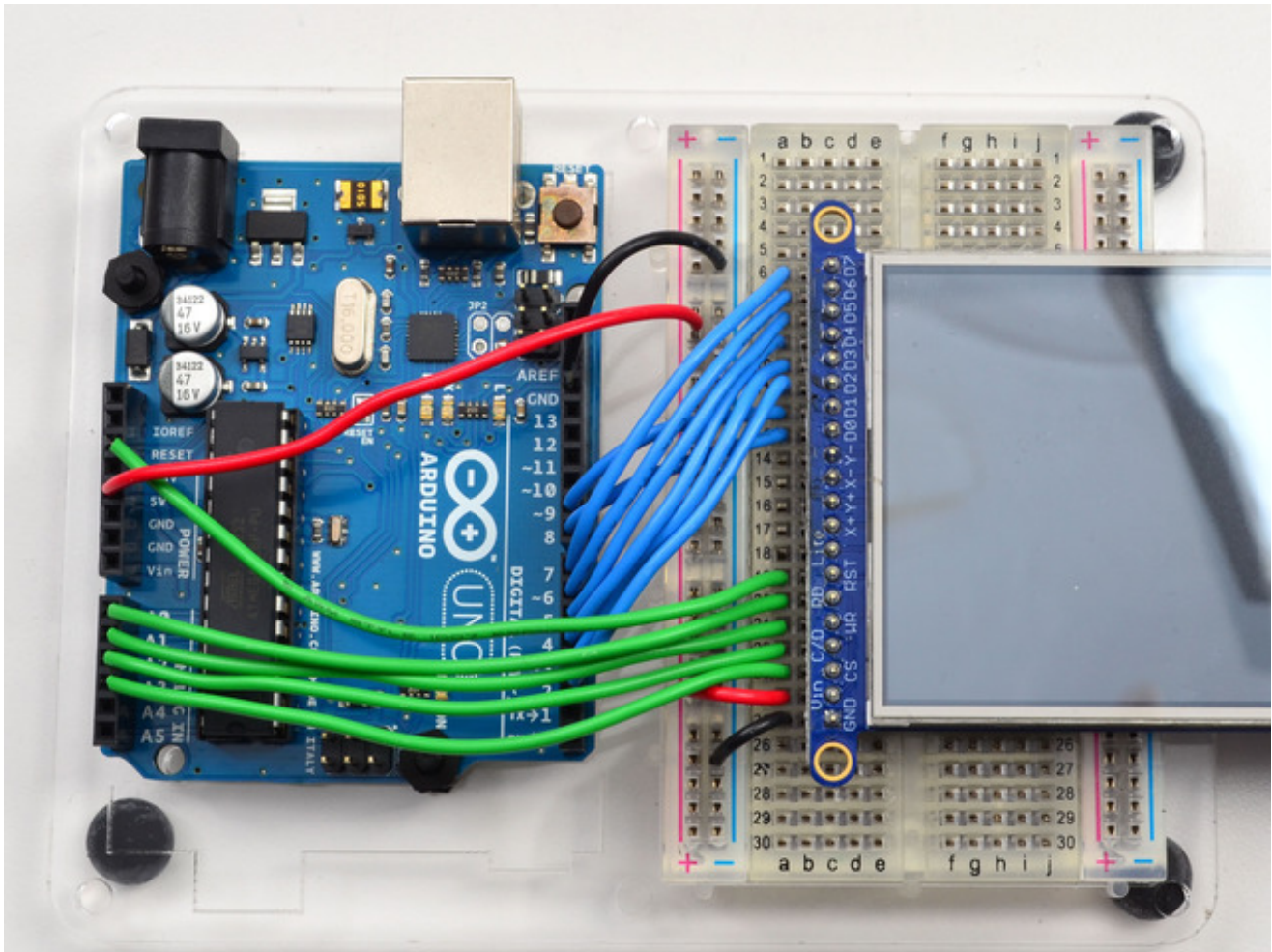
Now you can connect the remaining 6 pins over. Connect **D2-D7** on the TFT pins to digital **2** thru **7** in that order. If you're using a Mega, connect the TFT Data Pins **D2-D7** to Mega pins **#24-29**, in that order. Those Mega pins are on the 'double' header.





In addition to the 8 data lines, you'll also need 4 or 5 control lines. These can later be reassigned to any digital pins, they're just what we have in the tutorial by default.

- Connect the third pin **CS (Chip Select)** to Analog 3
- Connect the fourth pin **C/D (Command/Data)** to Analog 2
- Connect the fifth pin **WR (Write)** to Analog 1
- Connect the sixth pin **RD (Read)** to Analog 0



You can connect the seventh pin **RST (Reset)** to the Arduino Reset line if you'd like. This will reset the panel when the Arduino is Reset. You can also use a digital pin for the LCD reset if you want to manually reset. There's auto-reset circuitry on the board so you probably don't need to use this pin at all and leave it disconnected

The **RD** pin is used to read the chip ID off the TFT. Later, once you get it all working, you can remove this pin and the ID test, although we suggest keeping it since its useful for debugging your wiring.

OK! Now we can run some code

## 8-Bit Library Install

We have example code ready to go for use with these TFTs. It's written for Arduino, which should be portable to any microcontroller by adapting the C++ source.

Two libraries need to be downloaded and installed: first is the [Adafruit\\_TFTLCD](#)

[library \(http://adafru.it/aHk\)](http://adafru.it/aHk) (this contains the low-level code specific to this device), and second is the [Adafruit GFX Library \(http://adafru.it/aJa\)](http://adafru.it/aJa) (which handles graphics operations common to many displays we carry). If you have **Adafruit\_GFX** already, make sure its the most recent version since we've made updates for better performance

[Download Adafruit\\_TFTLCD Library](http://adafru.it/dcW)

<http://adafru.it/dcW>

[Download Adafruit\\_GFX Library](http://adafru.it/cBB)

<http://adafru.it/cBB>

Download both ZIP files, uncompress and rename the folders to **Adafruit\_TFTLCD** (contains **Adafruit\_TFTLCD.cpp** and **.h**) and **Adafruit\_GFX** (contains **Adafruit\_GFX.cpp** and **.h**) respectively. Then place them inside your **Arduinolibraries** folder and restart the Arduino IDE. If this is all unfamiliar, we have a [tutorial introducing Arduino library concepts and installation \(http://adafru.it/aYM\)](http://adafru.it/aYM).

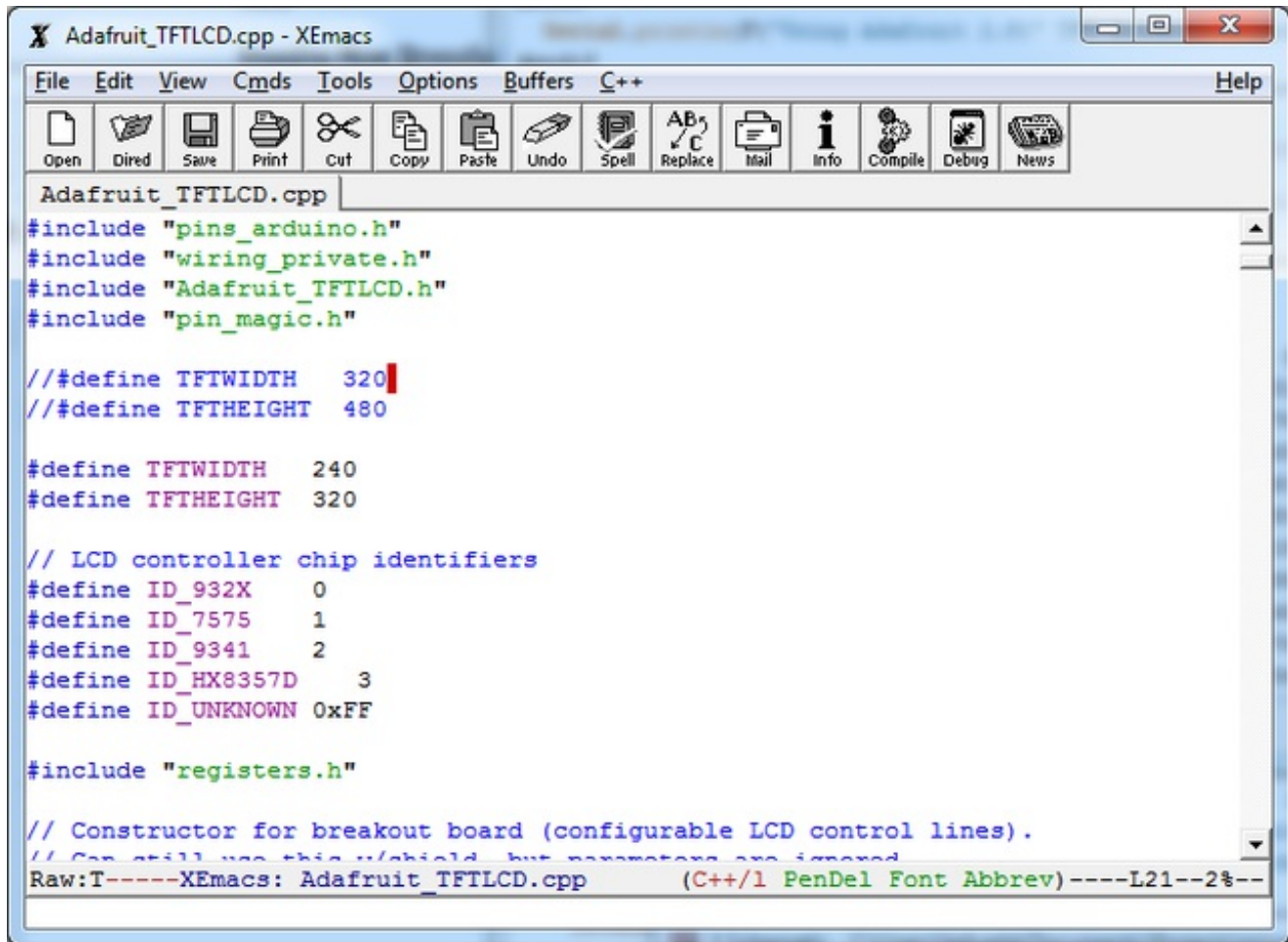
## Prepare TFTLCD Library

In the **Adafruit\_TFTLCD** Library folder, you may need to edit **Adafruit\_TFTLCD.h**. On about line 12, you will see

```
#define USE_ADAFRUIT_SHIELD_PINOUT
```

Make sure this line is commented out with `a//` in front (it should but if you're having issues, its worth checking).

Next up, we originally designed this library for 320x240 TFTs. Since this is a 480x320, we have to adjust the size the library is expecting. Open up **Adafruit\_TFTLCD.cpp** and find these lines:



```
Adafruit_TFTLCD.cpp
#include "pins_arduino.h"
#include "wiring_private.h"
#include "Adafruit_TFTLCD.h"
#include "pin_magic.h"

// #define TFTWIDTH 320
// #define TFTHEIGHT 480

#define TFTWIDTH 240
#define TFTHEIGHT 320

// LCD controller chip identifiers
#define ID_932X 0
#define ID_7575 1
#define ID_9341 2
#define ID_HX8357D 3
#define ID_UNKNOWN 0xFF

#include "registers.h"

// Constructor for breakout board (configurable LCD control lines).
// Can still use this w/ shield, but parameters are ignored.
Raw: T-----XEmacs: Adafruit_TFTLCD.cpp (C++/1 PenDel Font Abbrev) -----L21--2%--
```

Comment out the 240 and 320 lines, and uncomment the 320 and 480 lines:



```
Adafruit_TFTLCD.cpp
#include "pins_arduino.h"
#include "wiring_private.h"
#include "Adafruit_TFTLCD.h"
#include "pin_magic.h"

#define TFTWIDTH 320
#define TFTHEIGHT 480

// #define TFTWIDTH 240
// #define TFTHEIGHT 320

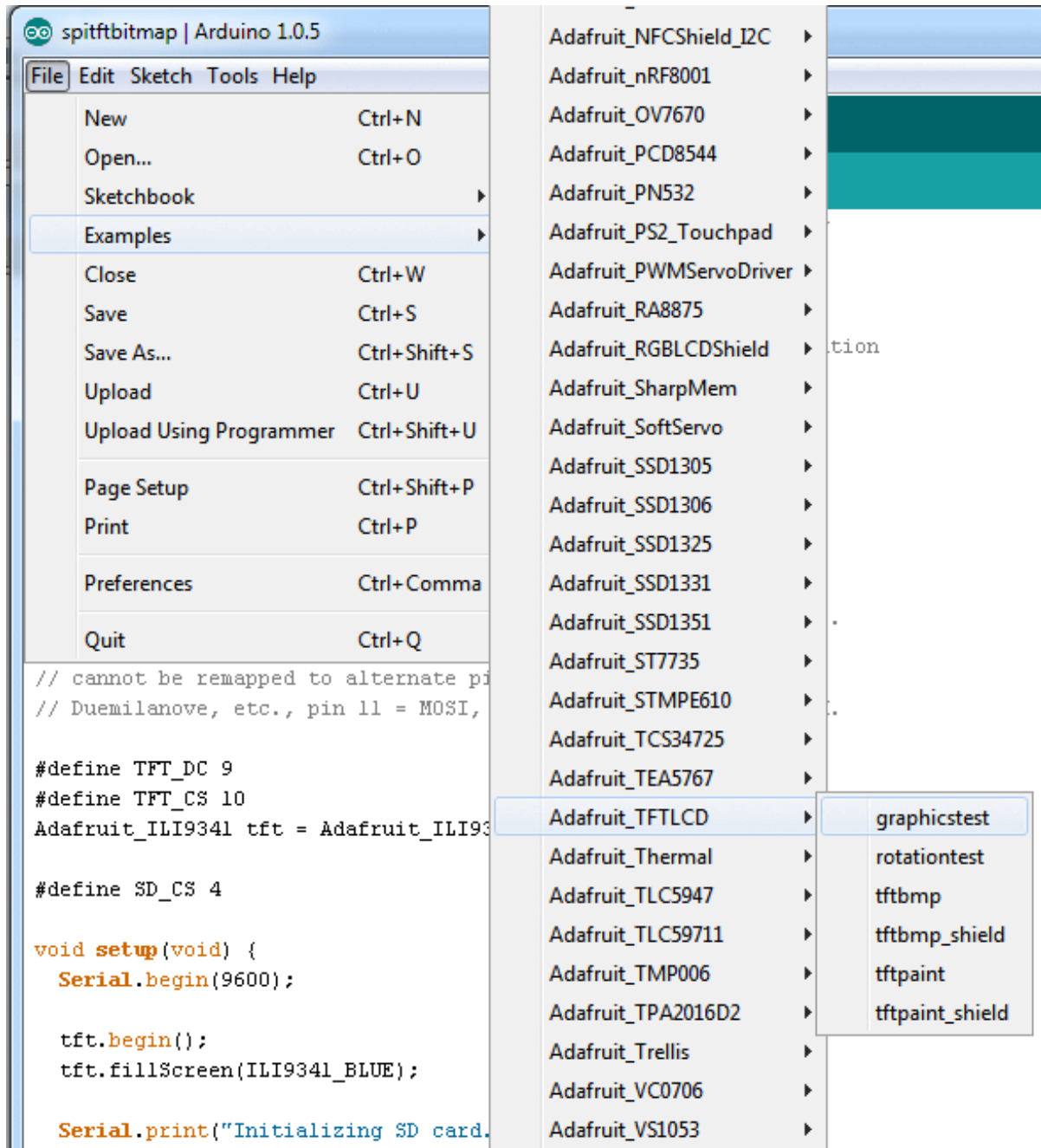
// LCD controller chip identifiers
#define ID_932X 0
#define ID_7575 1
#define ID_9341 2
#define ID_HX8357D 3
#define ID_UNKNOWN 0xFF

#include "registers.h"

// Constructor for breakout board (configurable LCD control lines).
// Can still use this w/ shield, but parameters are ignored.
Raw: T-----XEmacs: Adafruit_TFTLCD.cpp (C++/1 PenDel Font Abbrev) -----L34--2%
```

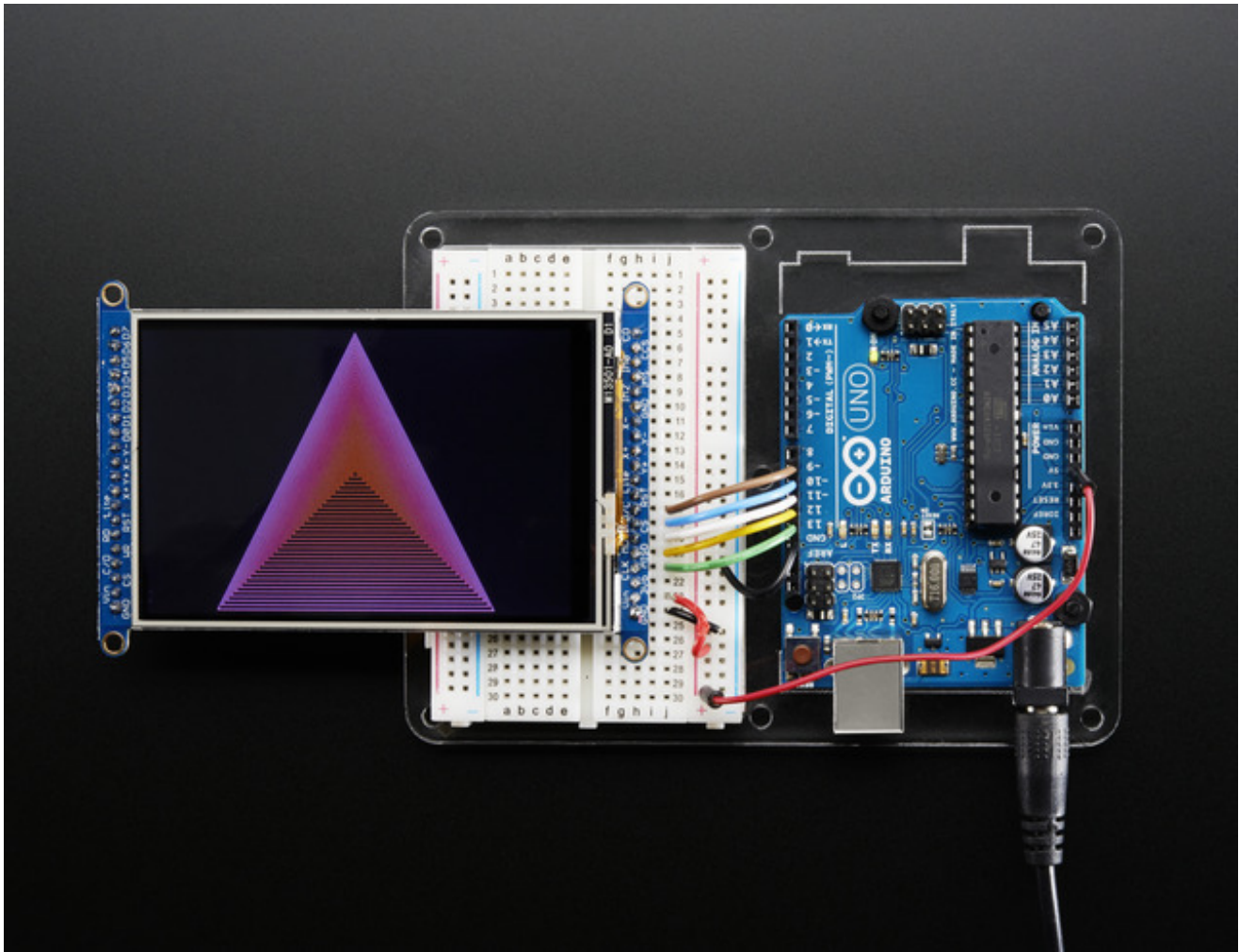
Save it, now you can upload the demo!

After restarting the Arduino software, you should see a new **example** folder called **Adafruit\_TFTLCD** and inside, an example called **graphicstest**. Upload that sketch to your Arduino.

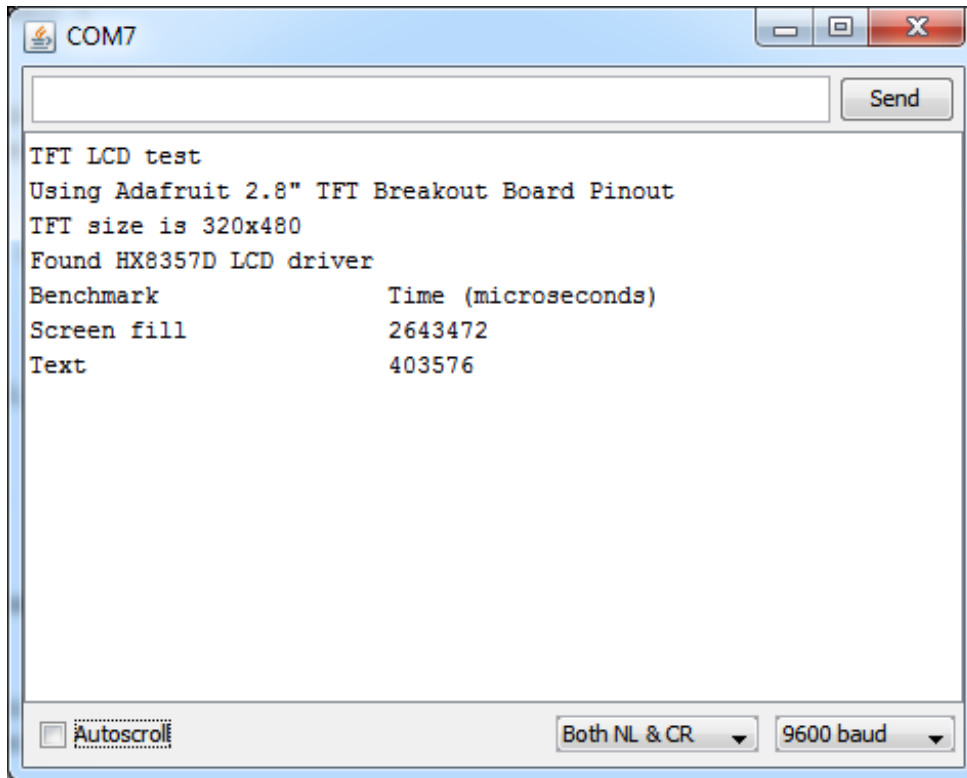


You may need to press the Reset button to reset the Arduino and TFT. You should see a collection of graphical tests draw out on the TFT.

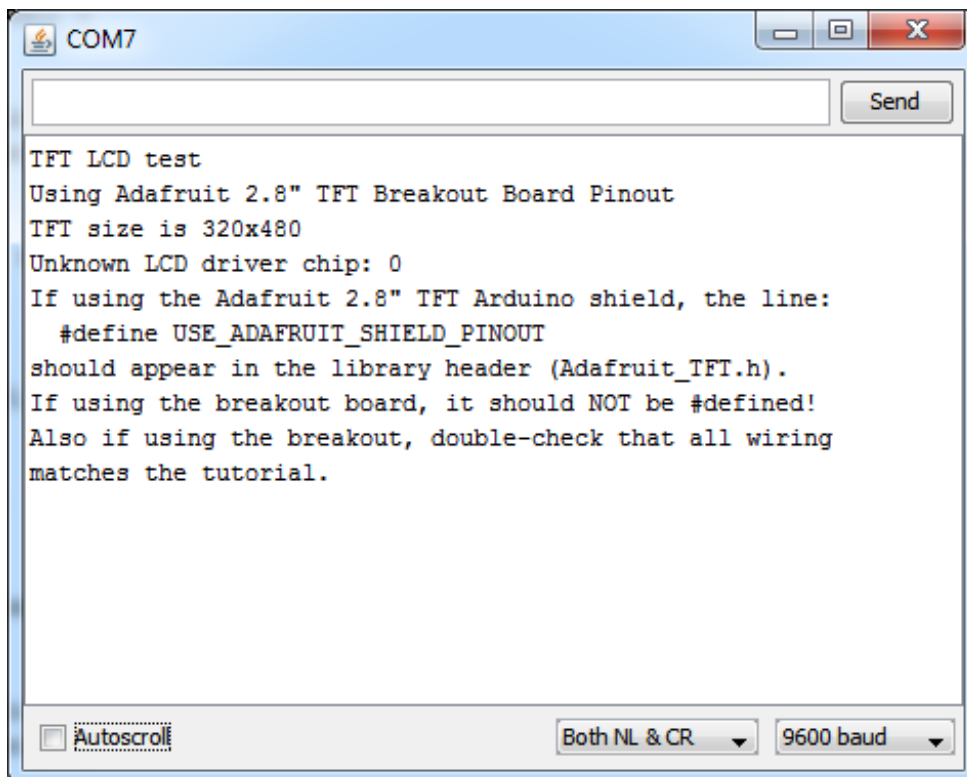
(The images below shows SPI wiring but the graphical output should be similar!)



If you're having difficulties, check the serial console. The first thing the sketch does is read the driver code from the TFT. It should be **0x8357** (for the **HX8357D** controller inside)



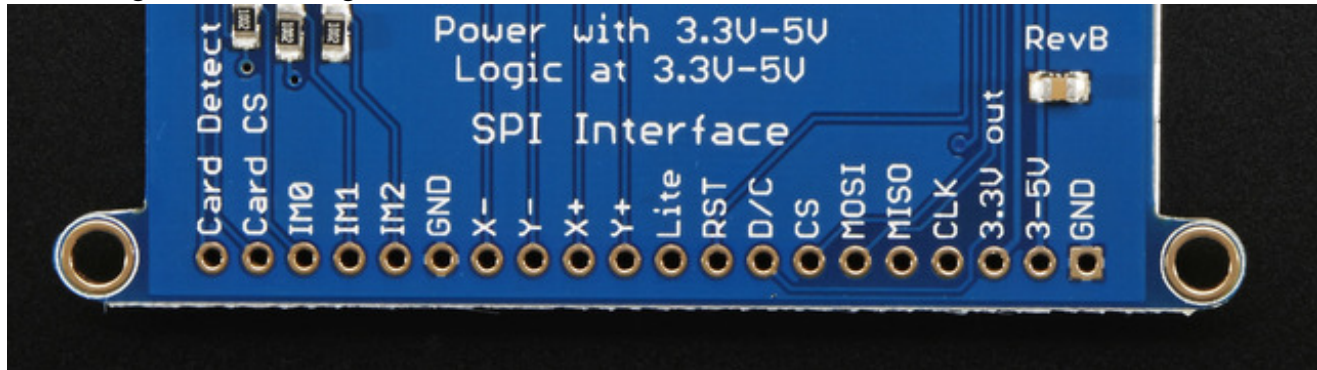
If you **Unknown Driver Chip** then it's probably something with your wiring, double check and try again!





# SPI Wiring & Test

Don't forget, we're using the SPI interface side of the PCB!

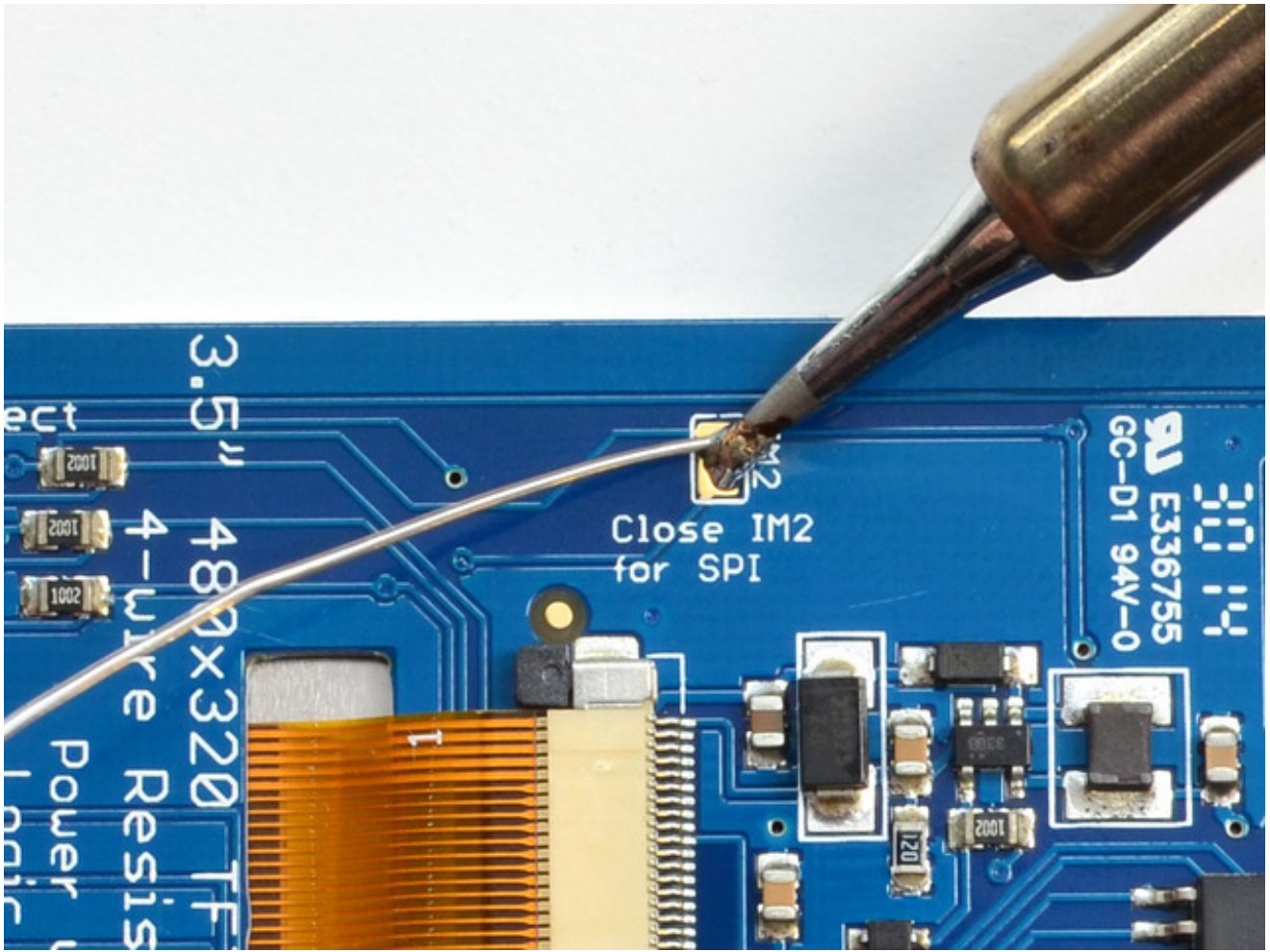


## SPI Mode Jumpers

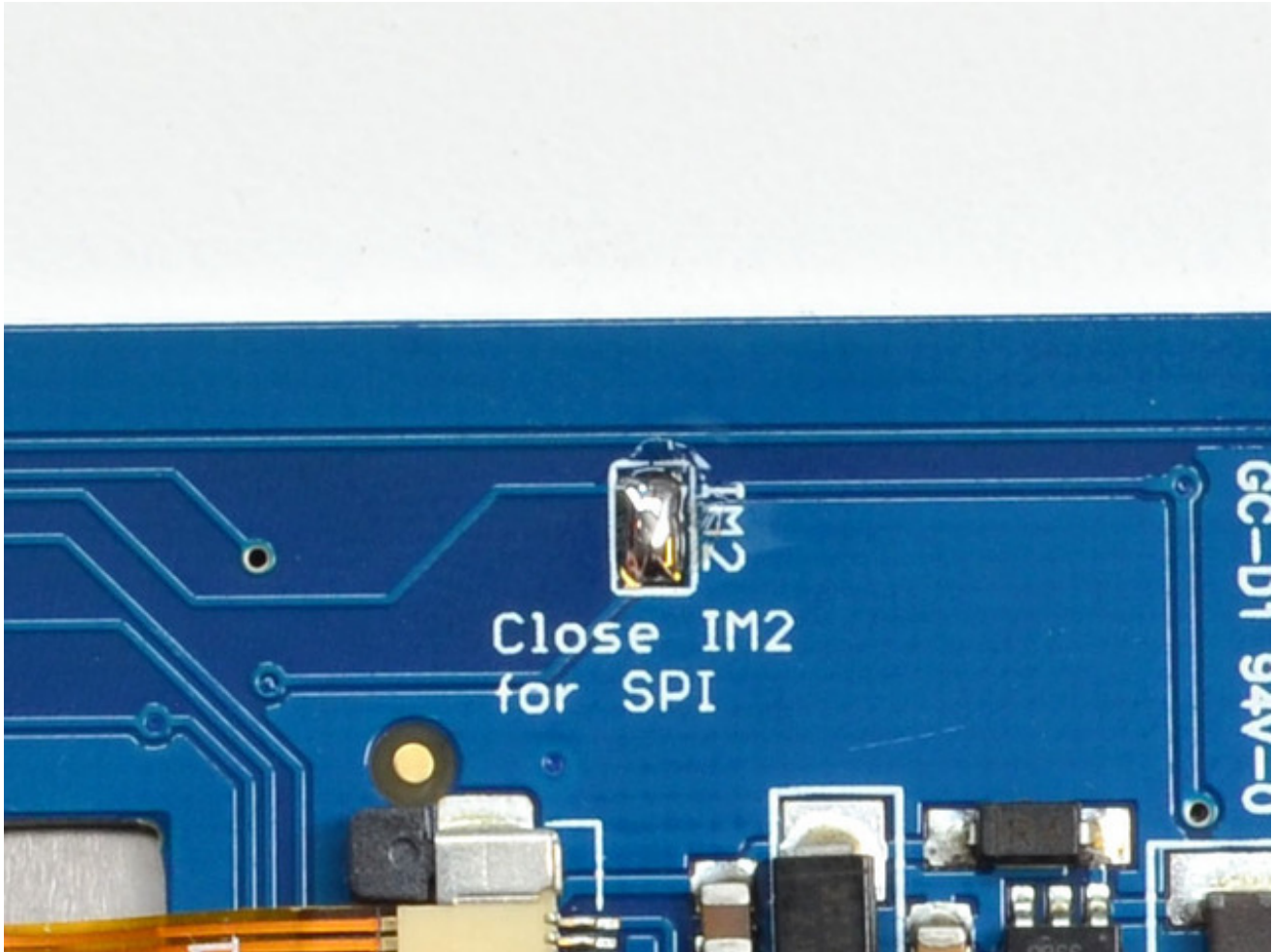
Before you start, we'll need to tell the display to put us in SPI mode so it will know which pins to listen to. To do that, we have to connect the **IM2** pin to 3.3V. The easiest way to do that is to solder closed the **IM2** jumper on the back of the PCB. Turn over the PCB and find the solder jumper:



With your soldering iron, melt solder to close the jumper indicated **IM2**







If you really don't want to solder, you can also wire the breakout pin to the **5V** pin, just make sure you don't tie it to 5V by accident! For that reason, we suggest going with the solder-jumper route.

## Wiring

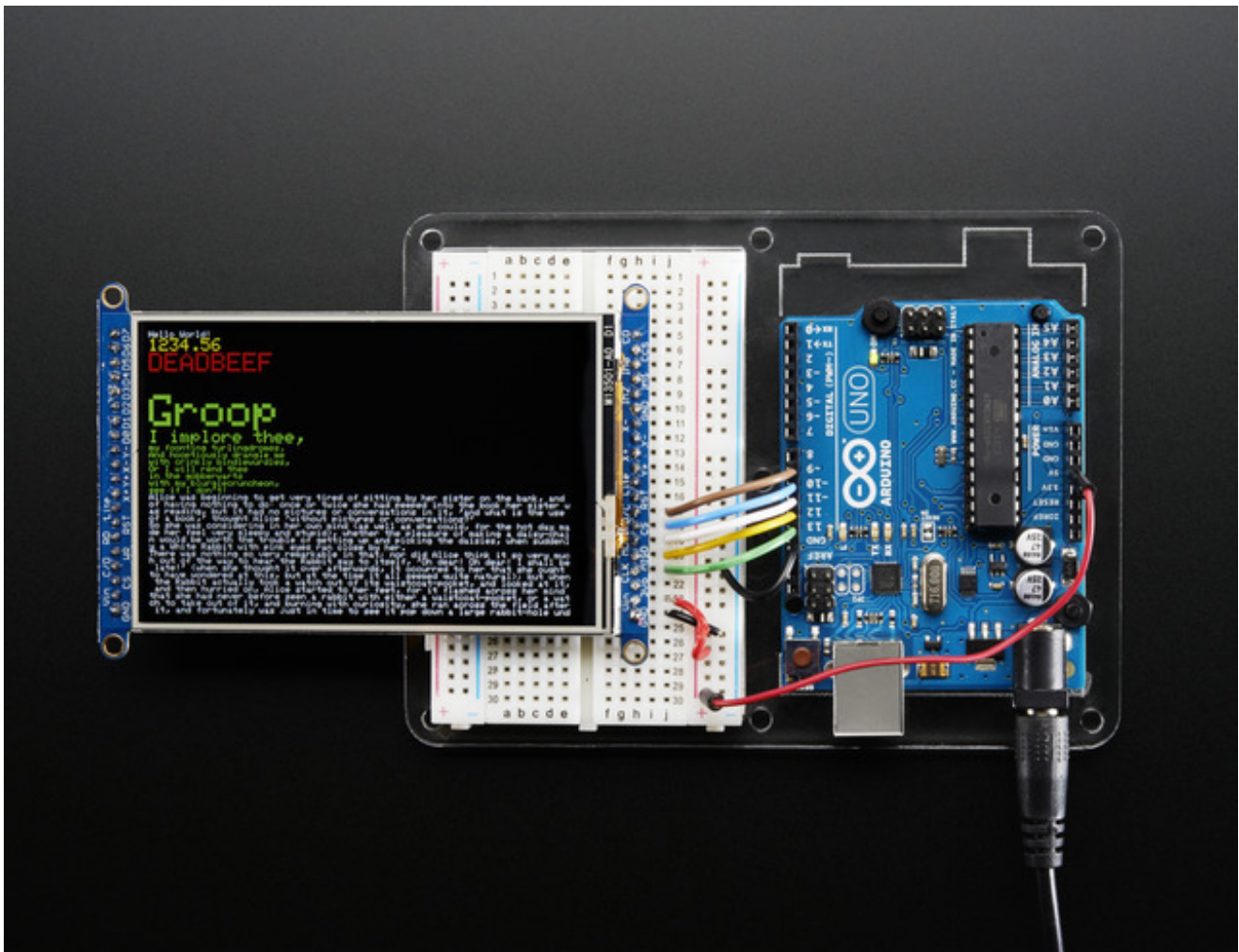
Wiring up the display in SPI mode is much easier than 8-bit mode since there's way fewer wires. Start by connecting the power pins

- **3-5V Vin** connects to the Arduino **5V** pin
- **GND** connects to Arduino ground
- **CLK** connects to SPI clock. On Arduino Uno/Duemilanove/328-based, that's **Digital 13**. On Mega's, it's **Digital 52** and on Leonardo/Due it's **ICSP-3** ([See SPI Connections for more details \(http://adafru.it/d5h\)](http://adafru.it/d5h))
- **MISO** connects to SPI MISO. On Arduino Uno/Duemilanove/328-based, that's **Digital 12**. On Mega's, it's **Digital 50** and on Leonardo/Due it's **ICSP-1** ([See SPI Connections for more details \(http://adafru.it/d5h\)](http://adafru.it/d5h))



- **MOSI** connects to SPI MOSI. On Arduino Uno/Duemilanove/328-based, that's **Digital 11**. On Mega's, it's **Digital 51** and on Leonardo/Due it's **ICSP-4** ([See SPI Connections for more details \(http://adafru.it/d5h\)](http://adafru.it/d5h))
- **CS** connects to our SPI Chip Select pin. We'll be using **Digital 10** but you can later change this to any pin
- **D/C** connects to our SPI data/command select pin. We'll be using **Digital 9** but you can later change this pin too.

That's it! You do not need to connect the **RST** or other pins for now.



## Install Adafruit HX8357 TFT Library

We have example code ready to go for use with these TFTs. It's written for Arduino, which should be portable to any microcontroller by adapting the C++ source.

Two libraries need to be downloaded and installed: first is the [Adafruit\\_HX8357 library \(http://adafru.it/dQW\)](http://adafru.it/dQW) (this contains the low-level code specific to this device), and

second is the [Adafruit GFX Library \(http://adafru.it/aJa\)](http://adafru.it/aJa) (which handles graphics operations common to many displays we carry). If you have **Adafruit\_GFX** already, make sure its the most recent version since we've made updates for better performance

[Download the Adafruit HX8357 Library](http://adafru.it/dR0)

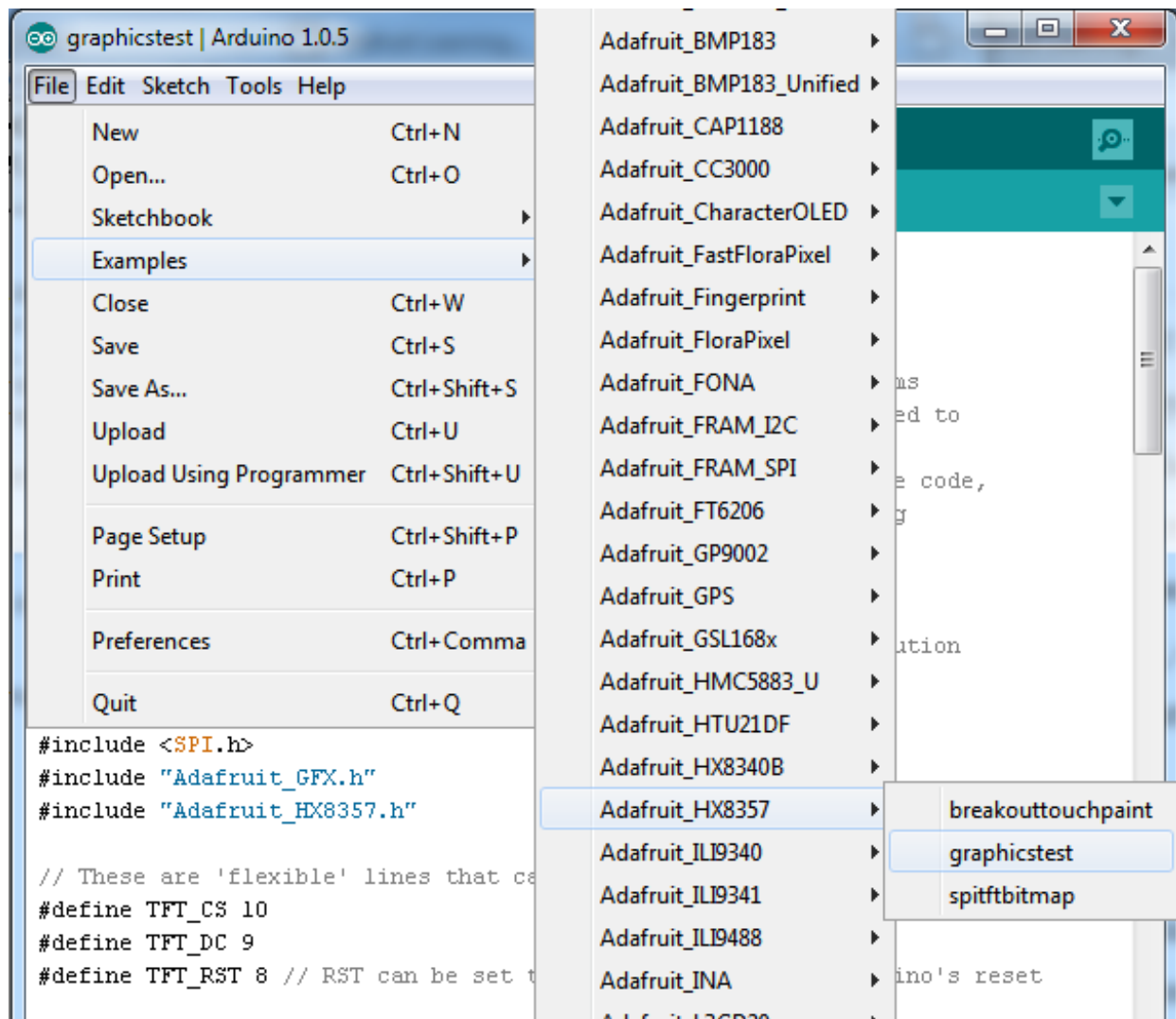
<http://adafru.it/dR0>

[Download the Adafruit GFX Library](http://adafru.it/cBB)

<http://adafru.it/cBB>

Download both ZIP files, uncompress and rename the folders to **Adafruit\_HX8357** (contains **Adafruit\_HX8357.cpp** and **.h**) and **Adafruit\_GFX** (contains **Adafruit\_GFX.cpp** and **.h**) respectively. Then place them inside your **Arduinolibraries** folder and restart the Arduino IDE. If this is all unfamiliar, we have a [tutorial introducing Arduino library concepts and installation \(http://adafru.it/aYM\)](http://adafru.it/aYM).

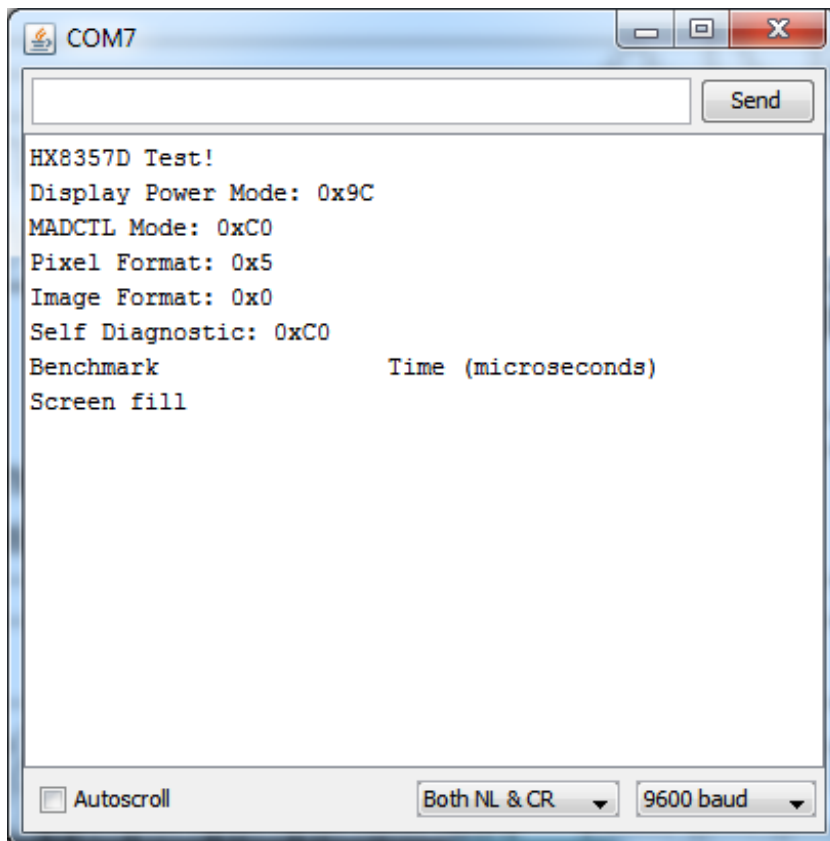
Restart the IDE



After restarting the Arduino software, you should see a new **example** folder called **Adafruit\_HX8357** and inside, an example called **graphicstest**. Upload that sketch to your Arduino. You may need to press the Reset button to reset the arduino and TFT. You should see a collection of graphical tests draw out on the TFT.

If you're having difficulties, check the serial console. The first thing the sketch does is read the driver configuration from the TFT, you should see the same numbers as below

**If you did not connect up the MISO line to the TFT, you wont see the read configuration bytes so please make sure you connect up the MISO line for easy debugging!** Once its all working, you can remove the MISO line

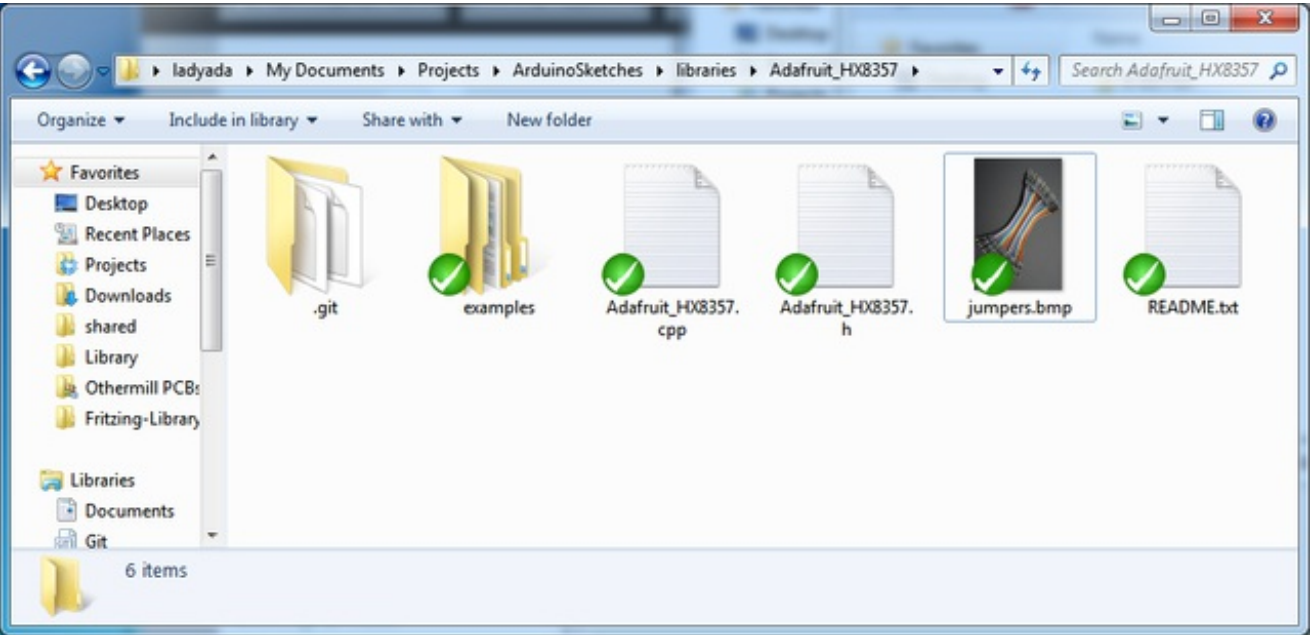


# Bitmaps (SPI Mode)

There is a built in microSD card slot into the breakout, and we can use that to load bitmap images! You will need a microSD card formatted **FAT16 or FAT32** (they almost always are by default).

Its really easy to draw bitmaps. **However, this is only supported when talking to the display in SPI mode, not 8-bit mode!**

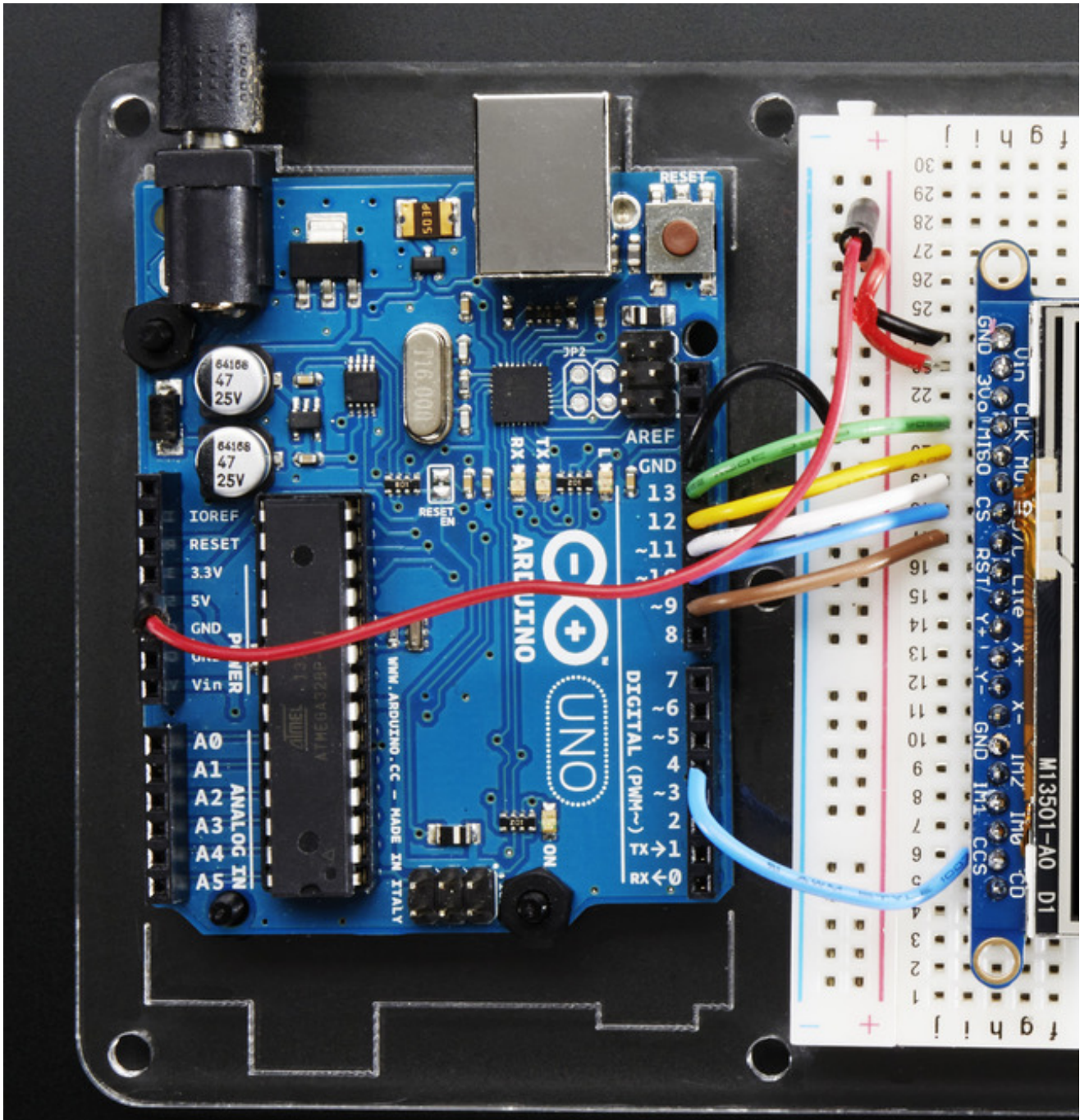
Find the **jumpers.bmp** file in the downloaded Arduino library



Copy **jumpers.bmp** into the base directory of a microSD card and insert it into the microSD socket in the breakout.

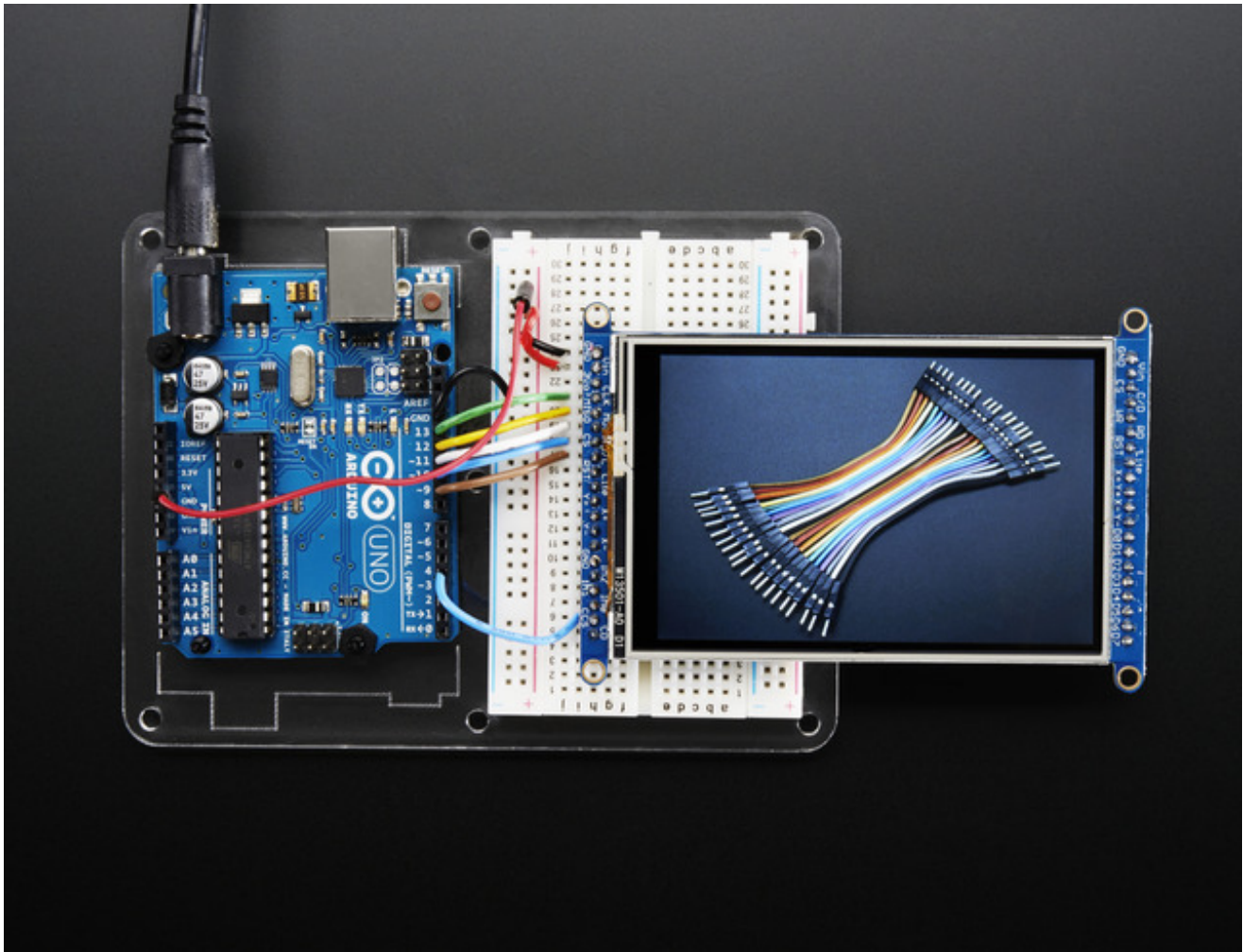
You'll need to connect up the **CCS** pin to **Digital 4** on your Arduino as well. See the image below





You may want to try the **SD library** examples before continuing, especially one that lists all the files on the SD card

Now upload the **file->examples->Adafruit\_HX8357->spitftbitmap** example to your Arduino + breakout. You will see the jumper wires appear!



To make new bitmaps, make sure they are less than 320 by 480 pixels and save them in **24-bit BMP format!** They must be in 24-bit format, even if they are not 24-bit color as that is the easiest format for the Arduino. You can rotate images using the **setRotation()** procedure

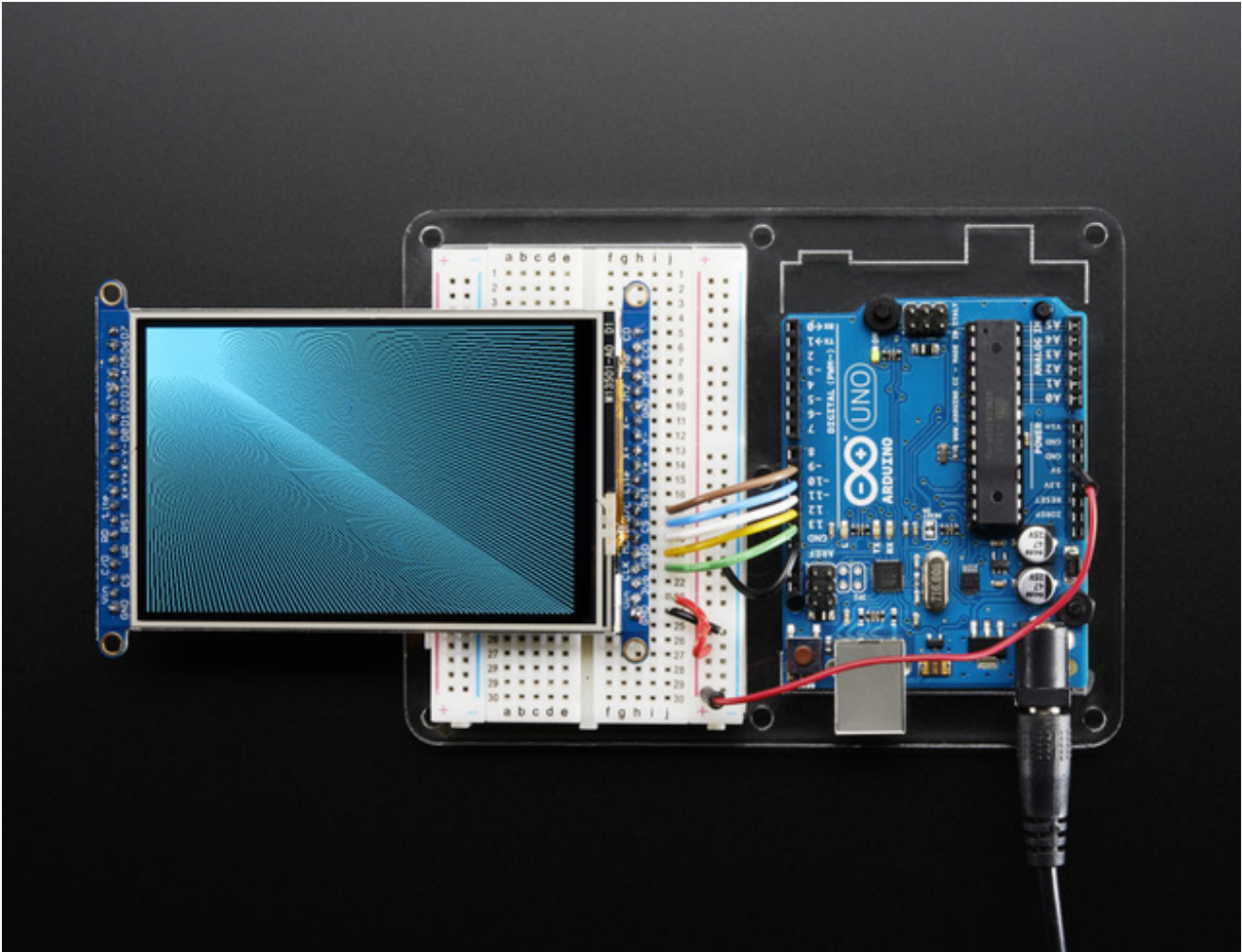
You can draw as many images as you want - dont forget the names must be less than 8 characters long. Just copy the BMP drawing routines below loop() and call

**bmpDraw(bitmapfilename, x, y);**

For each bitmap. They can be smaller than 320x480 and placed in any location on the screen.



# Adafruit GFX library



The Adafruit\_GFX library for Arduino provides a common syntax and set of graphics functions for all of our TFT, LCD and OLED displays. This allows Arduino sketches to easily be adapted between display types with minimal fuss...and any new features, performance improvements and bug fixes will immediately apply across our complete offering of color displays.

The GFX library is what lets you draw points, lines, rectangles, round-rects, triangles, text, etc.

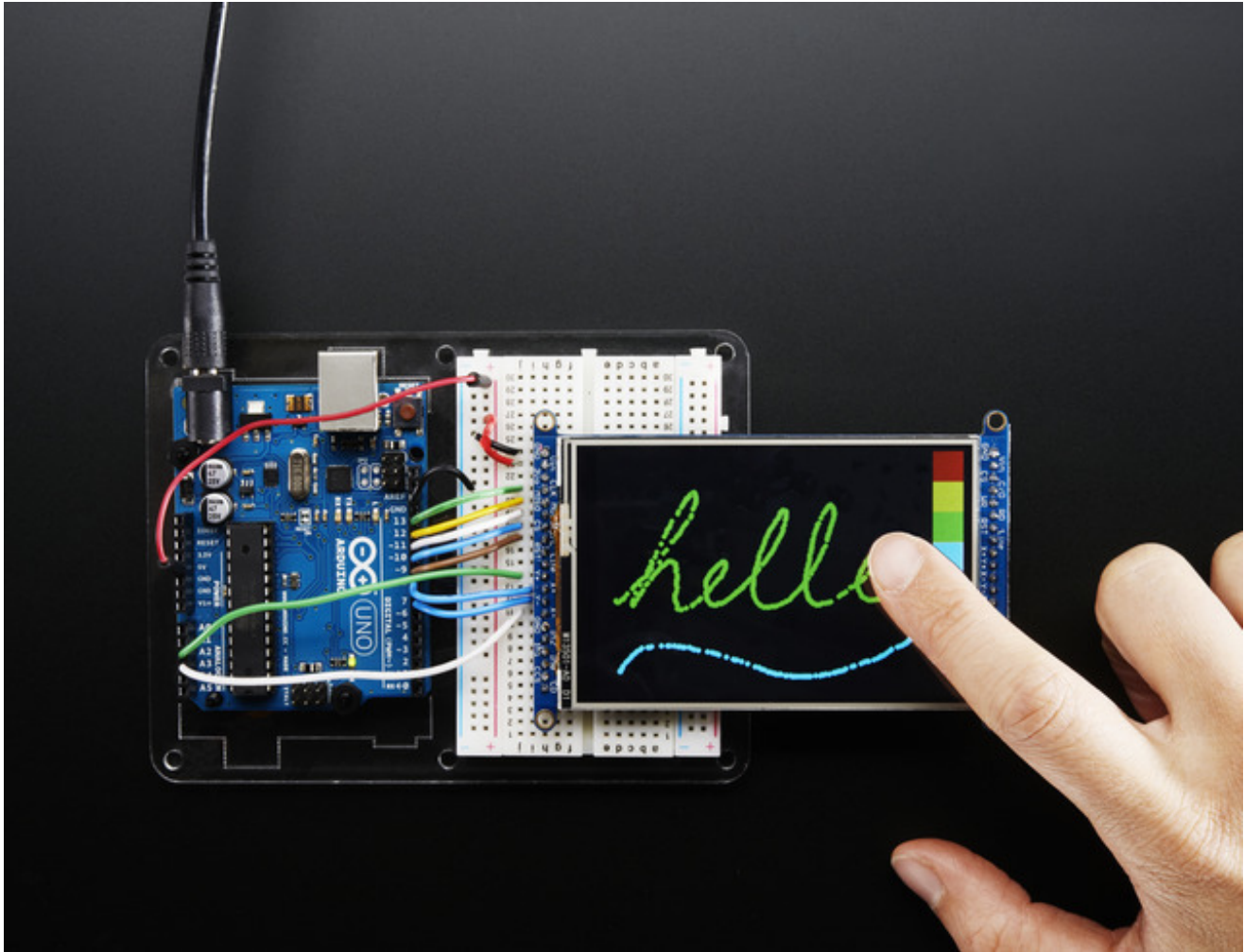
Check out our detailed tutorial here <http://learn.adafruit.com/adafruit-gfx-graphics-library> (<http://adafru.it/aPx>)

It covers the latest and greatest of the GFX library. The GFX library is used in both 8-bit

and SPI modes so the underlying commands (`drawLine()` for example) are identical!



# Touchscreen



The LCD has a 3.5" 4-wire resistive touch screen glued onto it. You can use this for detecting finger-presses, stylus', etc. You'll need 4 pins to talk to the touch panel, and at least 2 must be analog inputs. The touch screen is a completely separate part from the TFT, so be aware if you rotate the display or have the TFT off or reset, the touch screen doesn't "know" about it - its just a couple resistors!

We have a demo for the touchscreen + TFT that lets you 'paint' simple graphics. There's versions for both SPI and 8-bit mode and are included in the libraries. Just make sure you have gone thru the TFT test procedure already since this builds on that.

Remember, if you rotate the screen drawing with `setRotation()` you'll have to use `map()` or similar to flip around the X/Y coordinates for the touchscreen as well! It doesn't know about drawing rotation

# Download Library

Begin by grabbing our [analog/resistive touchscreen library from github](http://adafru.it/aT1) (<http://adafru.it/aT1>) (or just click the download button)

[Download Adafruit Touchscreen Library](http://adafru.it/dd0)

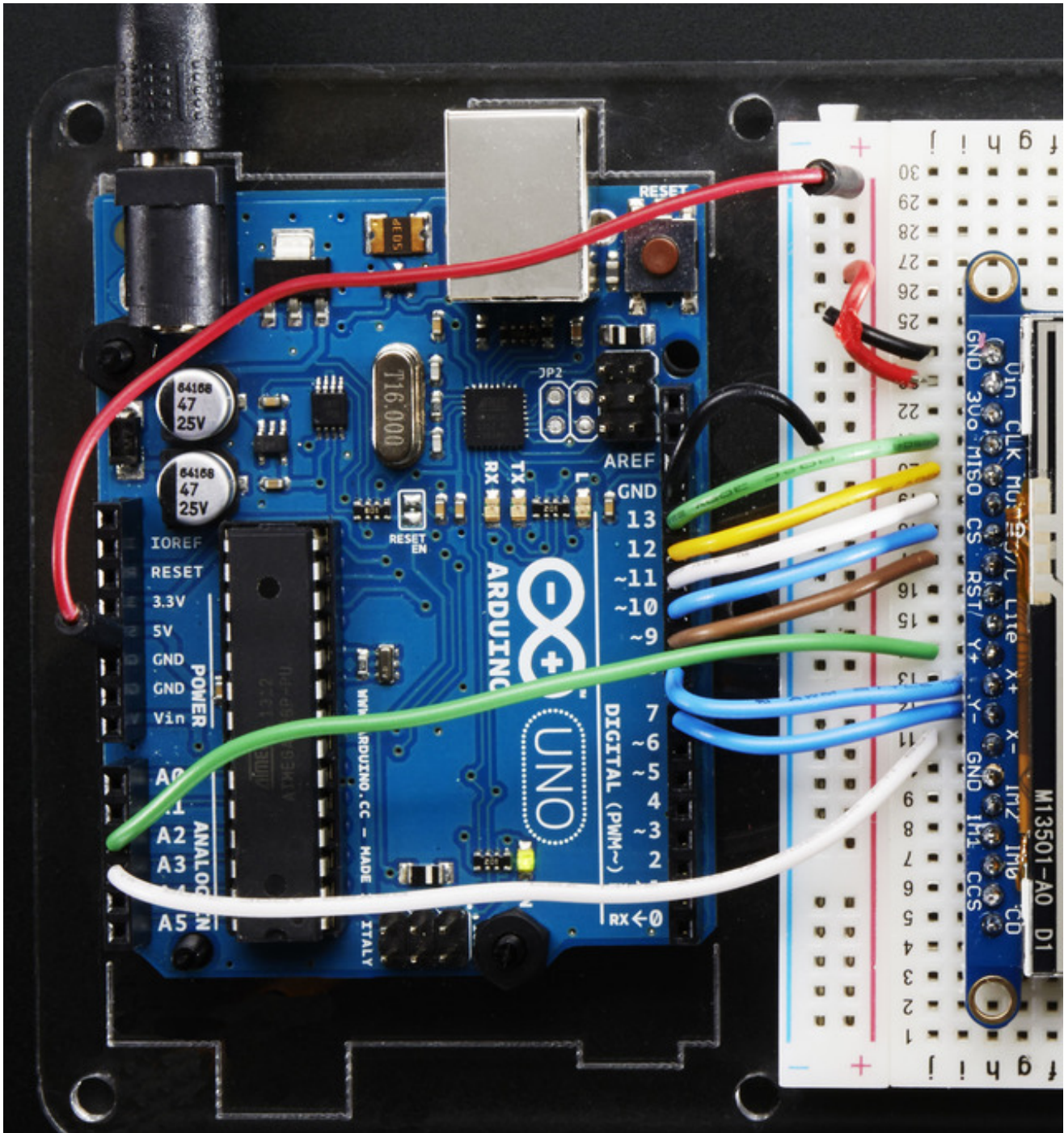
<http://adafru.it/dd0>

## Touchscreen Paint (SPI mode)

An additional 4 pins are required for the touchscreen. For the two analog pins, we'll use **A2** and **A3**. For the other two connections, you can pin any two digital pins but we'll be using **D8** and **D7** since they are available.

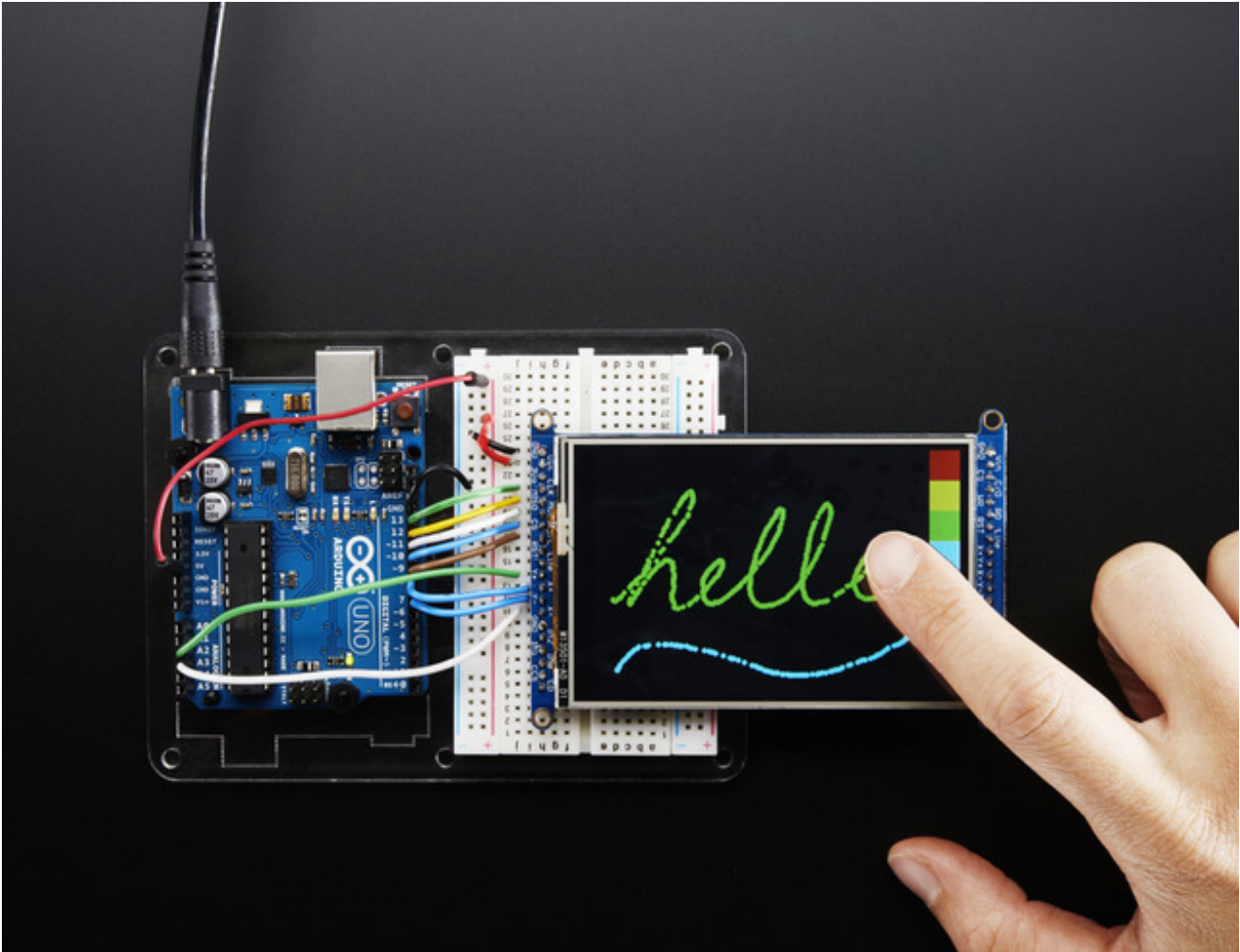
Wire the additional 4 pins as follows:

- Y+ to Arduino **A2**
- X+ to Arduino **D8**
- Y- to Arduino **D7**
- X- to Arduino **A3**



Load up the **breakoutTouchPaint** example from the **Adafruit\_HX8357** library and try drawing with your fingernail! You can select colors by touching the 'palette' of colors on the right





## Touchscreen Paint (8-Bit mode)

Another 4 pins seems like a lot since already 12 are taken up with the TFT **but** you can **reuse** some of the pins for the TFT LCD! This is because the resistance of the panel is high enough that it doesn't interfere with the digital input/output and we can query the panel in between TFT accesses, when the pins are not being used.

We'll be building on the wiring used in the previous drawing test for UNO

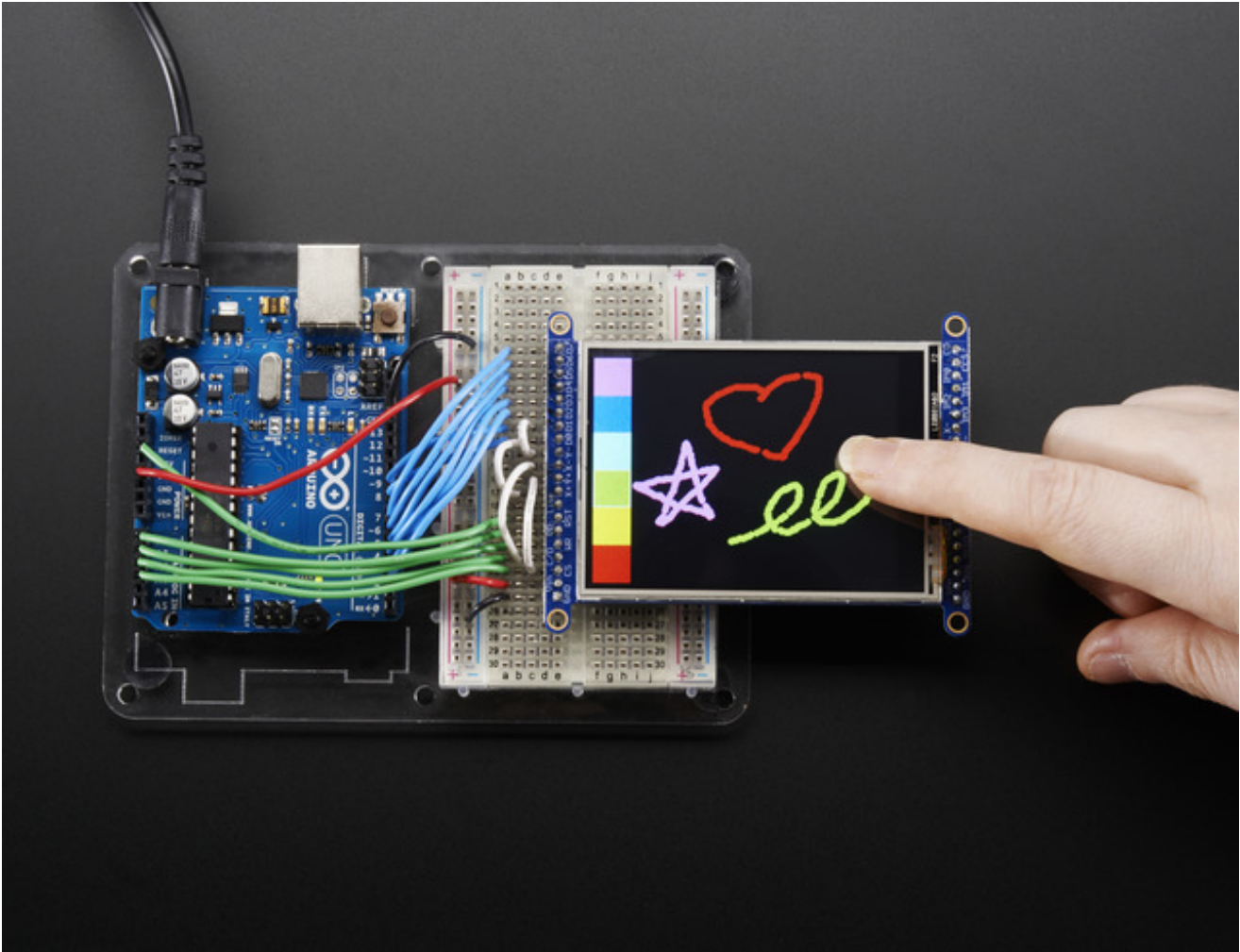
You can wire up the 4 touchscreen pins as follows. Starting from the top

- **Y-** connects to digital **#9** (also **D1**)
- The next one down (**X-**) connects to **Analog 2** (also **C/D**)
- The next one over (**Y+**) connects to **Analog 3** (also **CS**)
- The last one (**X+**) connects to digital **8**. (also **D0**)



The X- and Y+ pins pretty much have to connect to those analog pins (or to analog 4/5) but Y-/X+ can connect to any digital or analog pins.

The image below shows the wiring, its for the 2.8" TFT but its the same wiring setup



Load up the **tftpaint** example from the **Adafruit\_TFTLCD** library and try drawing with your fingernail! You can select colors by touching the 'palette' of colors on the right



# Downloads

# Datasheets & Files

- [Datasheet for the HX8357D chipset controller](http://adafru.it/dQQ) (http://adafru.it/dQQ)
- [Datasheet for the 3.5" TFT display \(raw\)](http://adafru.it/dR4) (http://adafru.it/dR4)
- [EagleCAD PCB files on GitHub](http://adafru.it/pBE) (http://adafru.it/pBE)
- [Fritzing object in Adafruit Fritzing library](http://adafru.it/aP3) (http://adafru.it/aP3)

# Schematic and PCB Print

