2.2" TFT Display
Created by lady ada
## Guide Contents

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Guide Contents</td>
<td>2</td>
</tr>
<tr>
<td>Overview</td>
<td>3</td>
</tr>
<tr>
<td>Pinouts</td>
<td>5</td>
</tr>
<tr>
<td>Assembly</td>
<td>6</td>
</tr>
<tr>
<td>Arduino Wiring</td>
<td>8</td>
</tr>
<tr>
<td>Arduino UNO or Compatible Wiring</td>
<td>8</td>
</tr>
<tr>
<td>Wiring for Other Boards</td>
<td>9</td>
</tr>
<tr>
<td>Arduino Code</td>
<td>10</td>
</tr>
<tr>
<td>Install Library</td>
<td>10</td>
</tr>
<tr>
<td>Run Graphics Test</td>
<td>10</td>
</tr>
<tr>
<td>Adafruit GFX Library</td>
<td>12</td>
</tr>
<tr>
<td>Bitmaps</td>
<td>12</td>
</tr>
<tr>
<td>Bitmaps</td>
<td>16</td>
</tr>
<tr>
<td>Troubleshooting</td>
<td>19</td>
</tr>
<tr>
<td>Display does not work on initial power but</td>
<td>19</td>
</tr>
<tr>
<td>does work after a reset.</td>
<td></td>
</tr>
<tr>
<td>Downloads</td>
<td>20</td>
</tr>
<tr>
<td>Files:</td>
<td>20</td>
</tr>
<tr>
<td>Alternative Wiring</td>
<td>21</td>
</tr>
<tr>
<td>Wiring</td>
<td>22</td>
</tr>
</tbody>
</table>

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https://learn.adafruit.com/2-2-tft-display  
Page 2 of 22
Overview

This lovely little display breakout is the best way to add a small, colorful and bright display to any project. Since the display uses 4-wire SPI to communicate and has its own pixel-addressable frame buffer, it can be used with every kind of microcontroller. Even a very small one with low memory and few pins available!

NOTE: This tutorial no longer covers the 176x220 pixel version of the display - only the newer 320x240 pixel version. Chances are you DO NOT have the older version!
The 2.2" display has 320x240 color pixels. Unlike the low cost "Nokia 6110" and similar LCD displays, which are CSTN type and thus have poor color and slow refresh, this display is a true TFT! The TFT driver (ILI9340) can display full 16-bit color. And the LCD will always come with the same driver chip so there's no worries that your code will not work from one to the other.

The breakout has the TFT display soldered on (it uses a delicate flex-circuit connector) as well as a ultra-low-dropout 3.3V regulator and a 3/5V level shifter so you can use it with 3.3V or 5V power and logic. We also had a little space so we placed a microSD card holder so you can easily load full color bitmaps from a FAT16/FAT32 formatted microSD card. The microSD card is not included but you can pick one up here (http://adafruit.it/102).
Pinouts

This color display uses SPI to receive image data. That means you need at least 4 pins - clock, data in, TFT CS and D/C. If you'd like to have SD card usage too, add another 2 pins - data out and card cs. However, there's a couple other pins you may want to use, let's go through them all!

- **GND** - this is the power and signal ground pin
- **Vin** - this is the power pin, connect to 3-5VDC - it has reverse polarity protection but try to wire it right!
- **D/C** - this is the TFT SPI data or command selector pin. Use 3-5V logic level
- **RESET** - this is the TFT reset pin. Connect to ground to reset the TFT! It's best to have this pin controlled by the library so the display is reset cleanly, but you can also connect it to the Arduino Reset pin, which works for most cases. There is an automatic-reset chip connected so it will reset on power-up. Use 3-5V logic level
- **SD Card CS / SDCS** - this is the SD card chip select, used if you want to read from the SD card. Use 3-5V logic level
- **LCD_CS** - this is the TFT SPI chip select pin. Use 3-5V logic level
- **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. Use 3-5V logic level
- **MISO** - this is the SPI Master In Slave Out pin, its used for the SD card. It isn't used for the TFT display which is write-only. It is 3.3V logic out (but can be read by 5V logic)
- **CLK** - this is the SPI clock input pin. Use 3-5V logic level
- **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. Use 3-5V logic level
Assembly

Start by connecting a piece of header to the display. This will make breadboarding much easier. Break off a piece of 0.1" header 9 pins long and place it into a breadboard, long pins facing down into the breadboard.

Place the display on top

Solder all the pins
Arduino Wiring

There are two ways to wire up these displays:

**Software SPI** is a more flexible method (you can use any pins on the Arduino) and **hardware SPI** is much faster (4-8x faster) but you are required to use the hardware SPI pins.

Since the display is quite large, we found that drawing would seem really slow if using 'software' SPI. For that reason, we'll show primarily how to wire up using hardware SPI and then how you can change the pins if desired.

Hardware SPI means that we have to connect the **CLK** and **MOSI** pins to fixed digital pins.

On '328 and '168 Arduinos, **CLK** must connect to digital 13 and **MOSI** must connect to digital 11. If using an Arduino Mega, connect **CLK** to 52 and **MOSI** to 51. If you're using another kind of Arduino you'll need to use the SPI hardware port (https://adafru.it/ICE)

Digital 10 (53 on Arduino Mega) must also be an output (but doesn't need to be connected to any particular pin).

**Arduino UNO or Compatible Wiring**

We'll use the following pin connections:

- **GND** connects to ground - black wire
- **VIN** connects to +5V - red wire
- **DC (data/clock)** connects to digital 9 on Atmega328
- Skip **SDCS** (SD card chip select - used for SD card interfacing)
- **CS** (chip select) connects to digital 10 on Atmega328
- **MOSI** (data out) connects to digital 11 on Atmega328
- **SCK** (clock) connects to digital 13 on Atmega328
- Skip **MISO** (data in - used for SD card interfacing)
Wiring for Other Boards

We'll use the following pin connections:

- **GND** connects to ground - black wire
- **VIN** connects to +5V - red wire
- **DC** (data/clock) connects to digital 9
- Skip **SDCS** (SD card chip select - used for SD card interfacing)
- **CS** (chip select) connects to digital 10
- **MOSI** (data out) connects to **MOSI**
- **SCK** (clock) connects to **SCK**
- Skip **MISO** (data in - used for SD card interfacing)

You can later change the CS and RST pins but to match the tutorial, use this connection diagram.

https://adafruit.it/AlM
https://adafruit.it/AlM
Arduino Code

Once you have the display wired up, its time to test your wiring by uploading the example code we have written. Again, we suggest using an Arduino to test.

Install Library

Go to the Arduino Library manager under Sketch -> Include Library -> Manage Libraries...

From within the Library manager, start by installing Adafruit GFX:

Then look for and install the Adafruit ILI9341 library

Note that this display has an ILI9340 but we still use the ILI9341 library, it's OK! The chips are nearly identical

One more! Look for and install Adafruit_ZeroDMA. That's the third and final library in this sequence.

You can read more about installing libraries in our tutorial(https://adafruit.it/aYG).

Run Graphics Test
Restart the Arduino IDE. You should now be able to select File > Examples > Adafruit_ILI9341 > graphicstest sketch. Upload the sketch to your Arduino wired as before.

Once uploaded, the Arduino should perform all the test display procedures! If you're not seeing anything - first check if you have the backlight on, if the backlight is not lit something is wrong with the power/backlight wiring. If the backlight is lit but you see nothing on the display make sure you're using our suggested wiring.
Adafruit GFX Library

We've written a full graphics library specifically for this display which will get you up and running quickly. The code is written in C/C++ for Arduino but is easy to port to any microcontroller by rewriting the low level pin access functions. Here are some of the functions we've included in the library.

The TFT LCD library is based off of the Adafruit GFX graphics core library. GFX has many ready to go functions that should help you start out with your project. Its not exhaustive and we'll try to update it if we find a really useful function. Right now it supports pixels, lines, rectangles, circles, round-rects, triangles and printing text as well as rotation.

Read more about it here! (https://adafruit.it/aPx)

Bitmaps

In this example, we'll show how to display a 220x176 pixel full color bitmap from a microSD card.
We have an example sketch in the library showing how to display full color bitmap images stored on an SD card. You'll need a microSD card such as this one (http://adafru.it/102). You'll also need to be running Arduino 1.0 or later, as the SD library was updated.

You'll also need an image. We suggest starting with this bitmap of a rose (https://adafru.it/cmm). If you want to later use your own image, use an image editing tool and crop your image to no larger than 160 pixels high and 128 pixels wide. Save it as a 24-bit color BMP file - it must be 24-bit color format to work, even if it was originally a 16-bit color image because of the way BMPs are stored and displayed!

Names for bitmap files **must not exceed 8 characters with a 3 character extension**. "mybitmap.bmp" is fine. "myotherbitmap.bmp" is too long and will not be readable by the SD file system.

Copy the **rose.bmp** to the microSD card and insert it into the back of the breakout board.
Wire up the TFT according to the high-speed SPI diagram above. Test that your wiring is correct by uploading the graphics test sketch with the high speed SPI line uncommented and the flexible-low-speed wiring commented.

Once you are sure that the TFT is wired correctly, add the two wires for talking to the SD card. Connect **CDCS** (the unconnected pin in the middle) to digital pin 4 (you can change this later to any pin you want) that's the orange wire below. Connect **MISO** (last unconnected pin) to the Arduino's hardware SPI **MISO** pin, that's the white wire below. For Classic arduinos, this is pin 12. For Mega's this is pin 50. You can't change the **MISO** pin, its fixed in the chip hardware.
Now load the **bitmap** example sketch into the Arduino. It should display the parrot image. If you have any problems, check the serial console for any messages such as not being able to initialize the microSD card or not finding the image.
Bitmaps

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).

![Image of microSD card slot](image)

Let's start by downloading this image of pretty flowers (pix by johngineer)

![Image of flowers](image)

Copy purple.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 SDCS pin to Digital 4 on your Arduino, and the MISO to MISO (or Digital #12 on an Uno) as well. In the below image, those are the extra purple & light blue wires.
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_ILI9341->spitftbitmap` example to your Arduino + breakout. You will see the flowers appear!

To make new bitmaps, make sure they are less than 240 by 320 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(bmpfilename, x, y);

For each bitmap. They can be smaller than 320x240 and placed in any location on the screen.
Troubleshooting

Display does not work on initial power but does work after a reset.
The display driver circuit needs a small amount of time to be ready after initial power. If your code tries to write to the display too soon, it may not be ready. It will work on reset since that typically does not cycle power. If you are having this issue, try adding a small amount of delay before trying to write to the display.

In Arduino, use `delay()` to add a few milliseconds before calling `tft.begin()`. Adjust the amount of delay as needed to see how little you can get away with for your specific setup.
Downloads

Files:

- Adafruit Fritzing Library (https://adafruit.it/aP3)
- ILI9340 (datasheet) (https://adafruit.it/CbV) controller with built in pixel-addressable video RAM buffer
- Display datasheet (https://adafruit.it/CbW)
- EagleCAD files on GitHub (https://adafruit.it/CbX)
Alternative Wiring

If you don't want to use the hardware SPI pins, it's easy to adjust the example sketches. Look for the top section where you can call the constructor as `Adafruit_HX8340B display(OLED_MOSI, OLED_CLK, OLED_RESET, OLED_CS)`. When all 5 arguments are passed to the display, it will automatically use the slower non-hardware-SPI interface. So you could uncomment that line and use any 5 pins you want.

```c
// Option 1: use any pins but much slower
//Adafruit_HX8340B display(OLED_MOSI, OLED_CLK, OLED_RESET, OLED_CS);

// Option 2: must use the hardware SPI pins
// (for UNO that's sclk = 13 and sid = 11) and pin 10 must be
// an output. This is much faster - also required if you want
// to use the microSD card (see the image drawing example)
Adafruit_HX8340B display(OLED_RESET, OLED_CS);
```

You cannot use software SPI if drawing image bitmaps from the SD card since the SPI interface is shared with the microSD card socket.

There's one last pin, the BL pin, which is used to control the backlight. By default the backlight is always on. You can control it, turning it off or PWM dimming, by connecting a digital/PWM pin. The backlight draws up to 50mA but there's a transistor wired up so you will find that you can use a 'weak' microcontroller pin to drive all 3 LEDs.