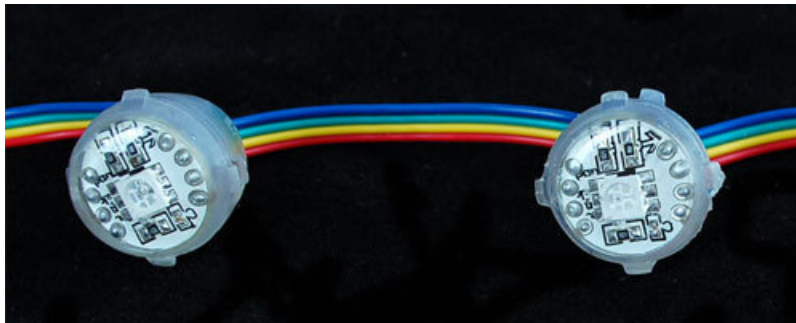




20mm LED Pixels

Created by Phillip Burgess



Last updated on 2019-11-15 05:30:59 PM UTC

Overview



Please note that Adafruit no longer sells this specific type of RGB LED pixel; the tutorial is for the benefit of customers with an existing collection of these pixels. For new projects we recommend our 12mm or 36mm LED pixels or digital LED strips.

RGB Pixels are digitally-controllable lights you can set to any color, or animate. Each pixel contains an RGB LED and a controller chip molded into a 'dot' of silicone, with flanges so they can be pushed into holes in thin sheet material. The dots are waterproof and rugged — they're typically used to make outdoor signs.

Basic stats

- 20mm diameter round waterproof pixels
- Approximately 3 inches (75mm) apart on 4-pin strand
- 5 Volts DC, 60 milliamps max per pixel (all LEDs on, full white)
- LPD6803 LED driver chip provides 15-bit color: [Datasheet \(https://adafru.it/alc\)](https://adafru.it/alc)
- 2-pin SPI-like protocol — easy for Arduino and other microcontrollers

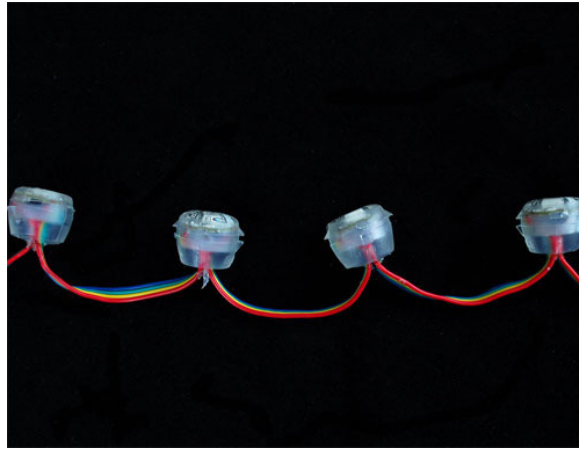
Here is a video showing our similar 12mm dots running a test pattern:



These pixels use a "5050" clear RGB LED and are brighter than our 12mm pixels. The trade off is that they are not diffused, so the color mixing is not as nice; close up, you can see the three separate LEDs. At 5 Volts, they draw a maximum of 60 mA per pixel: 20mA each for red, green and blue.



The LED pixels are spaced along a strand of ribbon cable, with about 3 inches or 75mm between pixels. If additional distance is needed you can cut the ribbon cable and solder 4 wires to extend the gap to the desired length.



Each pixel contains a small microchip within the silicone dot. The LPD6803 LED driver chip is custom designed for this purpose. These chips are very simple to communicate with — all they do is shift color data in from one pin and out another. To issue data from a microcontroller such as an Arduino, one "shifts out" 16 bits of color information. To write data to 10 LEDs, you would issue 160 bits ($10 * 16$). Following the data, 32 zero bits will "latch" the data and show the new LED colors.

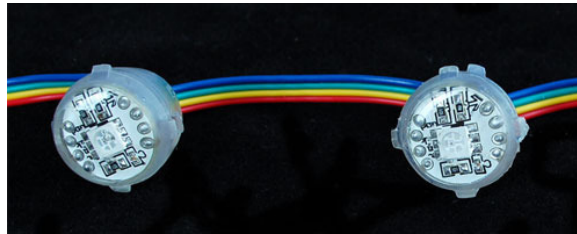
This chip can handle PWM for controlling color brightness, all it needs is a 'pixel PWM clock' which sets the PWM speed. The faster the clock, the smoother the color...but this signal has to travel all the way down the strand, so it can't be too fast or it'll snag the chips.

An interesting point is that the PWM clock is the same as the data clock. This is nice in that it saves a pin, but does mean that data must be carefully synchronized to the PWM counter in order to avoid unsightly flicker. This is okay but a little annoying because the PWM clock must be continuously issued, and on the Arduino this requires a timer interrupt and costs a fair chunk of CPU performance. We provide an Arduino library that takes care of all this unpleasantness behind the scenes, so you won't have to fuss with the details.

Wiring

The great thing about these pixels is that they're digitally controlled...that is, even though there are only two control lines (data and clock inputs), you can put as many pixels as you'd like in a single long strand, yet each one remains independently controllable.

Though it looks like the 4-conductor ribbon cable is continuous, *it isn't!* The ground and 5V lines pass through from one pixel to the next, but the two data control lines are different on the input and output sides. The input side goes to the LED driver chip, which then drives its own output to the next pixel in the strand.

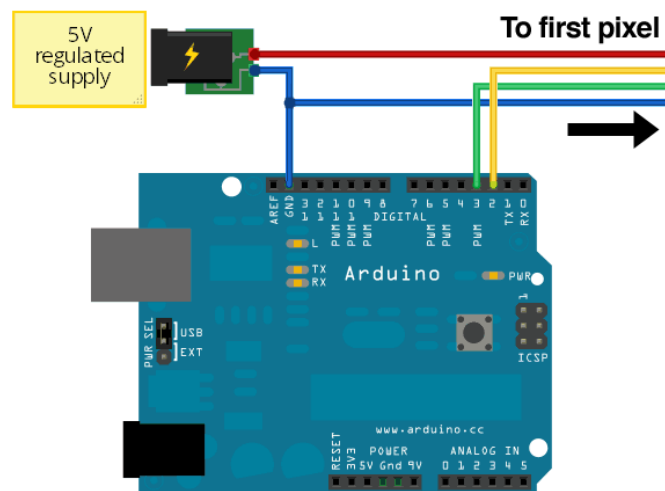


When connecting these pixels to a microcontroller, make sure you're connecting to the strand's **input** pins! Best way to distinguish the correct end is to examine the dots to find an arrow symbol. In the image above, the arrow is in the top right corner. The inputs are on the left and the signal passes to the right, following the direction of the arrow. If connecting multiple strands together, make sure the output of one strand goes to the input of the next.

Wiring is pretty easy since there are only 4 wires. The only important thing is that unless you are sure you will be using only a few of the LEDs at a time, you should not try to power the strip from the 5V on the Arduino. The Arduino is only meant to drive about 500mA of current, and as we saw earlier, a strand can take 1000mA or more if on! For that reason, we suggest powering with an external regulated 5V supply.

Connecting to Arduino

To use our example code for Arduino, connect the **yellow** wire (serial data) to Arduino **pin 2** and the **green** wire (serial clock) to **pin 3**. The software can be configured to use other pins, but we recommend using this arrangement when starting out, so that everything is tested in a known configuration. The **blue** wire (ground) should be connected to any of the Arduino **GND** pins.



Powering

When running a lot of LEDs, it's important to keep track of power usage. Individual LEDs don't get very hot or use tons of power, but they add up fast! Each single 20mm RGB LED pixel can draw up to 60mA from a 5V supply. That means a strand of 20 can use up to 1.2 Amps. That's a peak rate, which assumes that all the LEDs are on at full brightness. If most of the LEDs are kept dim or off (as when animating patterns), the average power usage can be 1/3 this or less.

Never, NEVER connect more than 5 Volts to the pixels! This will permanently damage them!

Connect ground to both your power supply and microcontroller. Then connect the 5V line from the power supply to the red wire on the LED strand. A large capacitor (1000uF or so) between 5V and ground is a nice addition to keep ripple down.

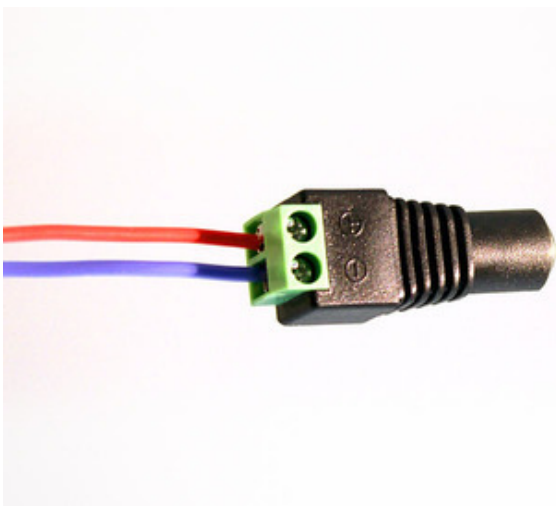
We suggest a nice switching supply for driving LED pixels:



Our [5 Volt, 2 Amp power supply \(http://adafru.it/276\)](http://adafru.it/276) is ideal for one strand of pixels.



For larger projects using multiple strands of pixels, our [5 Volt 10 Amp power supply \(http://adafru.it/658\)](http://adafru.it/658) is good for up to 8 strands (160 pixels total).



The [female DC power adapter \(http://adafru.it/368\)](http://adafru.it/368) mates with either of the above power supplies. Screw terminals clamp down on the power leads at the end of a strand, reducing the amount of soldering required.

Note the embossed polarity markings. Connect the **red wire** to the + terminal and the **blue wire** to the - terminal.

Tips for powering pixel strands:

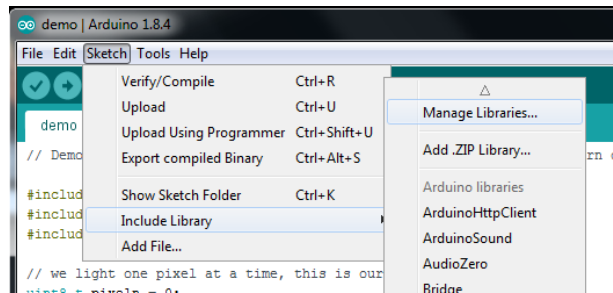
- When linking multiple strands together, power should be split and applied to *each* strand. If you try to power too many LEDs from just one end of the strand, they'll start to "brown out" the further they are from the power supply.
- Strands can be powered from *either* end — "input" and "output" doesn't apply to power, only the data signals from the microcontroller.
- If the 10 Amp power supply isn't large enough for your project, a [slightly modified ATX computer power supply \(https://adafru.it/aHR\)](https://adafru.it/aHR) can provide 30 Amps to power upwards of 500 pixels!
- Generally speaking, you should not try to power an LED strand from the Arduino's 5V line. This is okay if just a few pixels are lit, but is not adequate for driving a full strand.
- For a standalone application (not USB connected to a computer), you can power the Arduino from the same regulated 5V supply as the LEDs — connect to the 5V pin on the Arduino, *not* Vin, and don't use the DC jack on the Arduino.
- Remember to insulate or trim any unused, exposed power wires!

Code

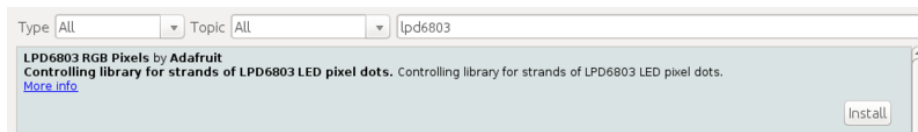
The Arduino library is heavily based off of [bliptronics'](https://adafru.it/ald) (https://adafru.it/ald) original code, except we library-ized it and trimmed it down.

The library can be installed from the Arduino library manager.

Open up the Arduino library manager:



Search for the **LPD6803** library and install it



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)

After installing the LPD6803 library, you should be able to access the sample code by navigating through menus in this order:

File→Sketchbook→Libraries→LPD6803→strandtest

Using the Library

The code to drive these dots is fairly simple, except that the PWM pin and the data clock pin are shared, meaning you can't just stick the PWM pin on a hardware timer output because then it's not possible to use it for the data clocking. Instead, the library uses an interrupt that goes off every few milliseconds. If there is data to be updated on the strip, it sends that data. If not, it just pulses pin to keep the PWM going.

Note that the interrupt uses Timer 1, meaning the pin 9 and 10 PWM outputs will not work for servos at the same time. If you need this capability, please use a 'software servo' library!

Let's look through the strandtest example code. To use the library in an Arduino sketch, you'll first need to globally declare an LPD6803 object to talk to the strip. It is invoked with three variables: the number of pixels and the data and clock pins:

```
int dataPin = 2; // 'yellow' wire
int clockPin = 3; // 'green' wire

// Set the first parameter to the NUMBER of pixels. 20 = 20 pixels in a row
LPD6803 strip = LPD6803(20, dataPin, clockPin);
```

Next, we initialize the strip in the setup() procedure:

```
void setup() {
  // The Arduino needs to clock out the data to the pixels
  // this happens in interrupt timer 1, we can change how often
  // to call the interrupt. setting CPUmax to 100 will take nearly all all the
  // time to do the pixel updates and a nicer/faster display,
  // especially with strands of over 100 dots.
  // (Note that the max is 'pessimistic', its probably 10% or 20% less in reality)
  strip.setCPUmax(50); // start with 50% CPU usage. up this if the strand flickers or is slow

  // Start up the LED counter
  strip.begin();

  // Update the strip, to start they are all 'off'
  strip.show();
}
```

setCPUmax() configures the Timer 1 interrupt that drives the strand. You can change this from 0 to 100, and it runs in the background. The 'max' is calculated assuming the longest possible timing (when sending data) so its a bit pessimistic. 50% should be plenty, you can mess with this to make the strip more or less

'flickery' You can change this 'on the fly' so for example set it to 0% just before doing a bunch of Ethernet stuff, then back to 50% later.

begin() actually starts the interrupt.

show() refreshes the displayed colors of the LEDs. You'll need to call show() after changing any pixel colors to see this reflected in the LEDs. This way you can change the entire strip at one time (it takes the same amount of time to change one pixel as it does for an entire strip, because the full strip data must be issued regardless).

Last, we'll look at an example function, colorWipe(). This creates a 'chase' sequence that fills the strip up with a color. It is basically a loop that increments through every pixel (which you can query with the numPixels() function) and sets the color of each (incremented with i) to the value passed (c — colors are expressed as a 16-bit variable type, though only the bottom 15 bits are used). The strip output is then updated with show(). Finally there is some delay (otherwise this would happen instantly).

Below that is a helper function that converts a color from separate 5-bit red, green and blue values into a combined 15-bit value (suitable for passing to colorWipe()). The brightness range is from 0 (off) to 31 (max brightness).

```
// fill the dots one after the other with said color
// good for testing purposes
void colorWipe(uint16_t c, uint8_t wait) {
  int i;

  for (i=0; i < strip.numPixels(); i++) {
    strip.setPixelColor(i, c);
    strip.show();
    delay(wait);
  }
}

/* Helper functions */

// Create a 15 bit color value from R,G,B
unsigned int Color(byte r, byte g, byte b)
{
  //Take the lowest 5 bits of each value and append them end to end
  return( ((unsigned int)g & 0x1F) << 10 | ((unsigned int)b & 0x1F) << 5 | (unsigned int)r & 0x1F);
}
```

For example, in the loop() function we call colorWipe(Color(31, 0, 0), 50) which will fill the strand with full-brightness red light, pausing about 50 milliseconds between pixels.

```
colorWipe(Color(31, 0, 0), 50); // red fill
colorWipe(Color(0, 31, 0), 50); // green fill
colorWipe(Color(0, 0, 31), 50); // blue fill
```


Troubleshooting

Many support issues arise from eager users getting ahead of themselves, changing the code and wiring before confirming that all the pieces work in the standard configuration. We recommend always starting out with the examples as shown. Use the pinouts and wiring exactly as in the tutorial, and run the stock, unmodified “strandtest” example sketch. Only then should you start switching things around.

Here are the most common issues and solutions...

- The pixels are wired and powered exactly as in the tutorial, the sketch compiles and uploads successfully, but nothing happens.
 - Double-check all wiring. Are the clock and data wires swapped? Is ground connected to the Arduino?
 - Confirm the Arduino is connected to the INPUT end of the strand.
 - Check power supply polarity and voltage. Are + and - swapped? If you have a multimeter, confirm 5V DC output ($\pm 10\%$) from the power supply.
 - Are the power wires at the opposite end of the strand insulated or trimmed? They should not be left exposed where they might make contact with metal, or each other.
 - Is the correct board type selected in the Arduino Tools→Board menu?

□ A few LEDs randomly turn on when power is applied, but then nothing happens.

The power supply is probably OK. Check for any of the following:

- Double-check all wiring. Are the clock and data wires swapped? Is ground connected to the Arduino?
- Confirm the Arduino is connected to the INPUT end of the strand.
- Is the correct board type selected in the Arduino Tools→Board menu?
- Did the strandtest code successfully compile and upload?

☐ Only the first few LEDs respond. The rest remain off or flicker randomly.

- Confirm that the number of LEDs in the LPD6803() constructor match the number of LEDs in the strand (both will be 20 if using the strandtest example and a single strand of LEDs).
- There may be a dodgy connection inside the first bad pixel or the one immediately before it. You can cut out the offending pixel(s) and join the two sub-strands.

□ The LEDs flicker randomly, not the way they're programmed to.

Are the clock and data wires swapped? Is ground connected to the Arduino?

📌 “White” LEDs are showing pink instead.

- This can happen when trying to power too long of a strand from one end. Voltage will drop along the length of the strand and the furthest pixels will “brown out.” Connect power to *every* 20 pixel strand.

📄 Sketch will not compile: error message is “LPD6803 does not name a type”

- Confirm the library is unzipped prior to installation.
- Confirm the library is properly named and located. The folder should be called LPD6803, and placed inside your personal Documents/Arduino/Libraries folder — *not* inside the Arduino application folder!
- After installation, the Arduino IDE needs to be restarted for new libraries to be used.

