BLOG

By Eli Hughes (https://workspace.circuitmaker.com/User/Details/Eli-Hughes) · Feb 13 2016

Guest Blog - Fun with SuperLEDS

Lights, motion, sound… produce any combination of these effects and humans are interested, and sometimes awed. Whether it be a blockbuster film, a high profile rock show, or a choreographed fireworks display - lights, motion, and sound let us know that something is *happening*.

For this blog, let's focus on the lighting aspect. Electroluminescence was first discovered in 1907 by an ancestral maker by the name of H.G. Round. Many years later, in 1927, a Soviet maker named Olef Losev came up with a "Light Emitting Diode" (LED) in the lab. But, it wasn't until 1962 that Nick Holonyak designed and built the first practical (i.e. mass manufacturable) LED while working at General Electric. Since then, makers have been using them anywhere and everywhere for user interfaces, "idiot lights," and just cool visual effects.

It wasn't long before someone wanted to use thousands (or millions) of them to create large displays. Since that time, there have been many techniques to multiplex large numbers of LEDs to make them easier to control with a logic circuit. Even with the use of shift registers, microprocessors, multiplexers, and lots of drive transistors, creating large LED displays can involve quite a bit of work.

Introducing "SuperLEDs"

In the past few years there has been a sort of evolution in LED technology - not so much in the LEDs themselves, but in the integrated electronics available for driving them. To aid in the design of very large arrays of LEDs, there are nicely packaged "super LEDs" that are easy to daisy chain into a very large, customized display. The idea is to combine the LED with integrated drive electronics in a small, low pin count package that employs a high speed serial interface to chain LEDs together. Asian manufacturers are producing these "super

LEDs" in enormous volumes, and the maker community is benefitting from this industry of scale. There are several options, like the WS2812B, the APA102C, the SK2812, etc. (to name a few). In this blog, I am going to focus on my personal favorite, the APA102C.

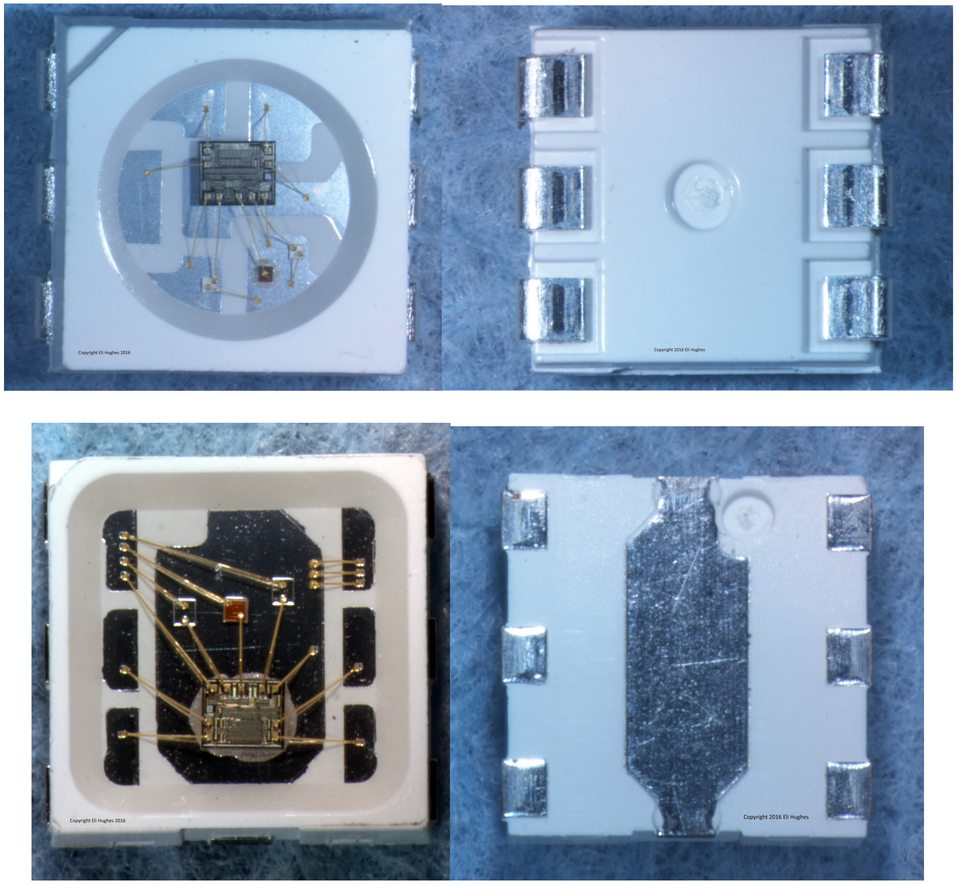

Figure 1: The APA102C (Top) and APA102 (Bottom).

There are two variants of this device - the APA102 and the APA102C. The non "C" version uses high brightness LEDs and has additional metalization on the package for heatsinking. When they say high high brightness, they mean it! Even the "low brightness" version will leave you dazzled with blue flash dots lingering on your retinas! When I refer to "APA102," I mean either one of the devices.

Synchronous vs. Asynchronous

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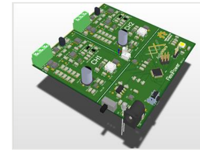
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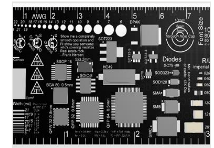
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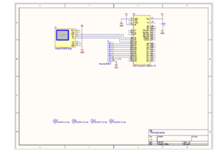
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One of the differentiating features between the the APA102 and other super LEDs is their control interface. All super LEDs can be wired in a large daisy chain, meaning that data goes in one side and comes out the other. The APA102, specifically, uses a 2-wire, synchronous communications interface. There is a separate clock and data signal that can be driven as a synchronous serial stream (e.g. SPI). Other super LED modules such as the WS2812B use a single wire for communication. In this configuration, data bits are differentiated by the width of a pulse. This scheme is asynchronous in nature, requiring the transmitter and receiver to use precise timing references.The advantage of this approach is that you save one wire in the interface at the cost of complexity in the data encoding.

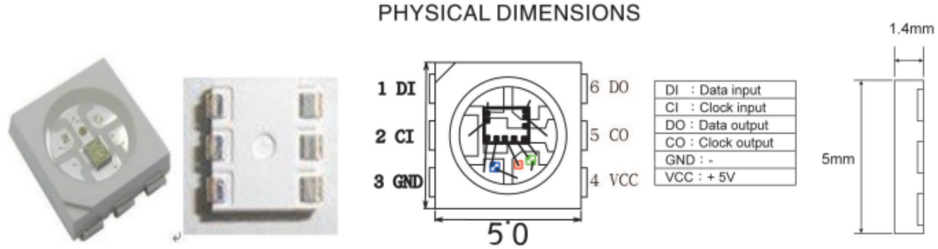
I prefer the APA102, as high speed synchronous serial protocols are always faster and more fault tolerant than asynchronous ones. The asynchronous protocol of the WS2812B requires a tight software loop or dedicated hardware (FPGA, timer automation, etc.). For my needs, the simplicity of the synchronous interface of the APA102 and its flexibility outweighs the requirement of the extra control wire. When routing signals on a PCB, the CLK and DATA signals can travel together and do not add a lot of additional time or complexity to the routing process. There are also some other advantages of the APA102, such as the PWM refresh rate. The color intensity of the APA102 is controlled via a pulse width modulated (PWM) current internal to the device. The WS2812B uses a 400Hz PWM rate for controlling intensity. The APA102 uses a much higher rate of 19.2KHz. While 400Hz seems adequate, it is visibly noticeable in moving patterns across an array of devices.

Let’s take a look at some specs for the APA102. Figure 2 is the the “Reader’s Digest” version of what the the APA102 is all about.

PRODUCT SPECIFICATIONS

Model number	Color	Millicandela	refresh rate	Applied voltage	Power consumption	View angle	weight (g)	Dimensions(mm) L x W x D	Operating temperature
SUPER LED	Full Color 16777216	R 500-650 mcd G 370-530 mcd B 120-165 mcd	400 cycle	5VDC	0.2W (MAX:1W)	H:160	0.1	5x5x1.4	-40°C~70°C

PHYSICAL DIMENSIONS



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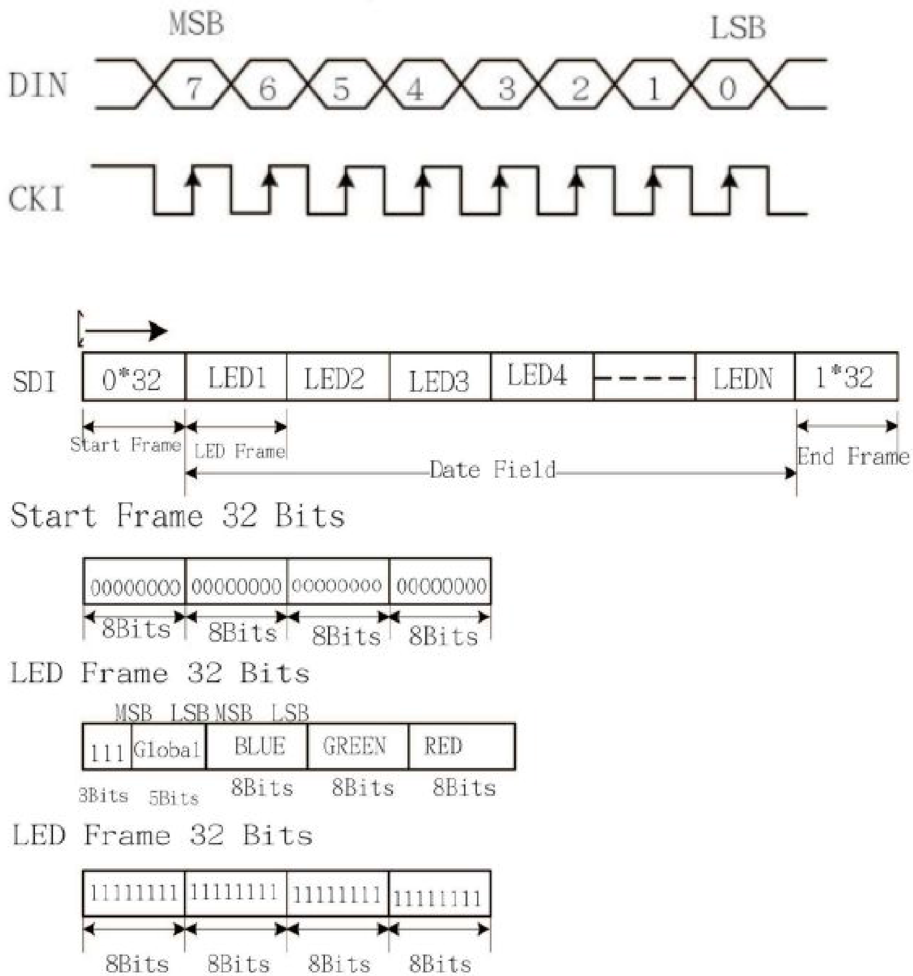

Figure 2: APA102 Details

From Figure 2, a good hacker could probably extrapolate how one would use the device. Luckily, there is plenty of info out there about how to program the devices in delightfully juicy detail.

https://cpldcpu.wordpress.com/2014/08/27/apa102/ (https://cpldcpu.wordpress.com/2014/08/27/apa102/)

https://cpldcpu.wordpress.com/2014/11/30/understanding-the-apa102-superled/ (https://cpldcpu.wordpress.com/2014/11/30/understanding-the-apa102-superled/)

Tim’s blog links to some nice C code on how to program the devices. Adafruit also has resources on the APA 102. (https://learn.adafruit.com/adafruit-dotstar-leds/overview) Note that Adafruit markets these LEDs as “DotStar.” The WS2812B is marketed as “NeoPixel.”

It is a bit difficult to pin down the “official” manufacturer of the part, but I got plenty of details from APA Electronic Co. LTD. (http://www.neon-world.com/) There are a handful of other Asian manufacturers producing the part, but to make life easy, you can easily find suppliers on Octopart (https://octopart.com/search?q%3DAPA102%26start%3D0). If you want to save some money, you can go directly to Asia and order from AliExpress (like I do!) though bear in mind the supply chain risks involved.

But, here is the **really** cool part. You can purchase these LEDs in individual units, on flexible strips, or in a matrix array (https://octopart.com/search?q%3DRGB%2520LED%2520matrix%26start%3D0) format. Just do a search to see a wide variety of product available.

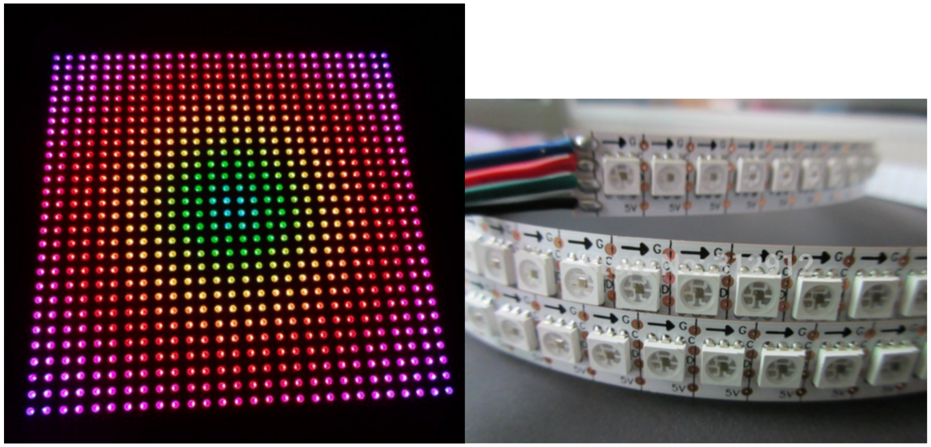

Figure 3: The APA102 used in different formats

If you are the type to make your own stuff from scratch, there is already a model in CircuitMaker. I built a 4” ring of 32 APA102C devices (http://workspace.circuitmaker.com/Projects/222AFB23-BC10-4AB7-A8BB-A683E9A108C0). You can use this project as a starting point for your own creation. There is a model of the APA102C ready to go. You also get to see how to make a complex board outline in Circuitmaker. Here is the board in action!

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