Project Y0Chain: APA102C addressable LED analysis

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2023-10-18

1 Overview

The APA102C addressable LEDs are spec'ed for 5V but we want to use them lower. I got a couple of LED strips (sparkfun) and connected the tigard to be able to script some tests.

TLDR: no big surprises but lessons are

- can operate to really low V,
- tweak brightness before colour, and use brightness to turn leds off
- blue and green (~10-12mA) are cheaper than red (~18-20mA), but some time muxing is going on or something because white (all on) is about 27mA/LED
- if using 12 LEDs, you should have more than 2 hours of full on, 100% blasting, all LEDs for every 1000mAh the LiPo has.

With a 400mAh battery, you could in theory get 1 full hour of full on. Manage your colours, spend more time in blue and green, alternate which LEDs are on, or be off half the time and you can increase this greatly. For example, with full white but brightness down to 10/31, the 400mAh would last over 100 minutes.

These are guesstimates based on the limited strips I have here but I'd say we're ok if you strobe or breathe the LEDs a bit.

1.1 Lower Bounds

They do rather well all the way down to 3.0V (with diminish brightness). Crossing thresholds causes stepped distortions, with artifacts appearing as we go below the forward voltage of the individual colours, which appear to be around:

- blue Vf: 2.9V
- green Vf: 2.2V

1.2 Brightness vs Power Supply

For comparison of brightness vs source V (current), a string of 6 RGB LEDs, set to white (r=g=b=0xff) and max brightness (31), were measured using a light meter at ~30 cm. At various supply voltages, this provides:

V	lux	mA
3.0	121	145
3.3	170	189
3.7	235	241
4.0	277	272
5.0	286	321

Short version: we're good until the LiPo dies, and can operate within the 3v3-3v7 range while maintaining nice colour fidelity.

1.3 Knobs

Other than the source voltage itself, we have two knobs to play with:

1. the actual colour we set, between 0 - 0xff; and
2. a global "brightness" value for a LED (5 bits, 0 - 0x1f)

All I have is a lux meter–not the best tool do deal with LEDs–but it is interesting to note that (using 8 LEDs):

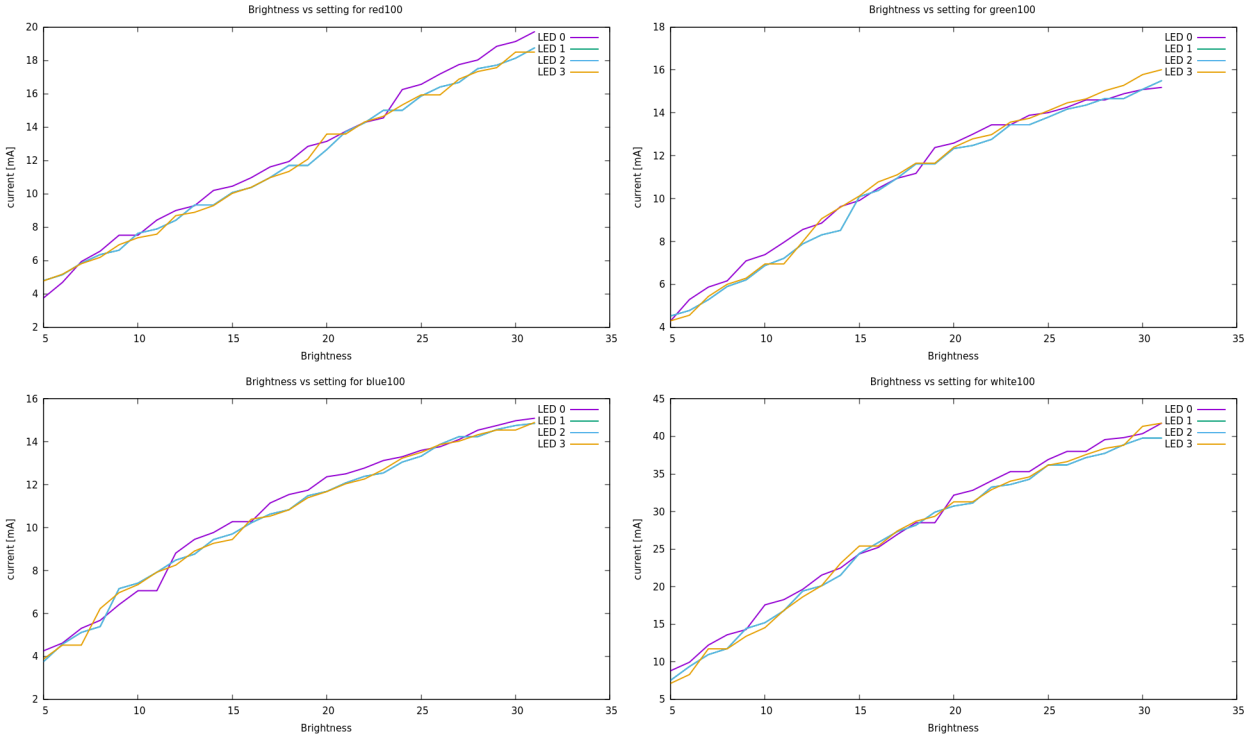
r,g,b	brightness	lux	mA	comment
0xff	0x1f	198	214	full col, full bright
0x7f	0x1f	137	138	50% col, full bright
0xff	0x0f	173	165	full col, half bright
0xff	0x0a (10)	158	134	full col, low bright*
0xff	0	0	2.6mA	min cost of ownership
0x00	0x1f	0	7.3mA	useless leakage

using full blast white (100% on r,g and b) but a low brightness (last row), yields the bestest lux/mA.

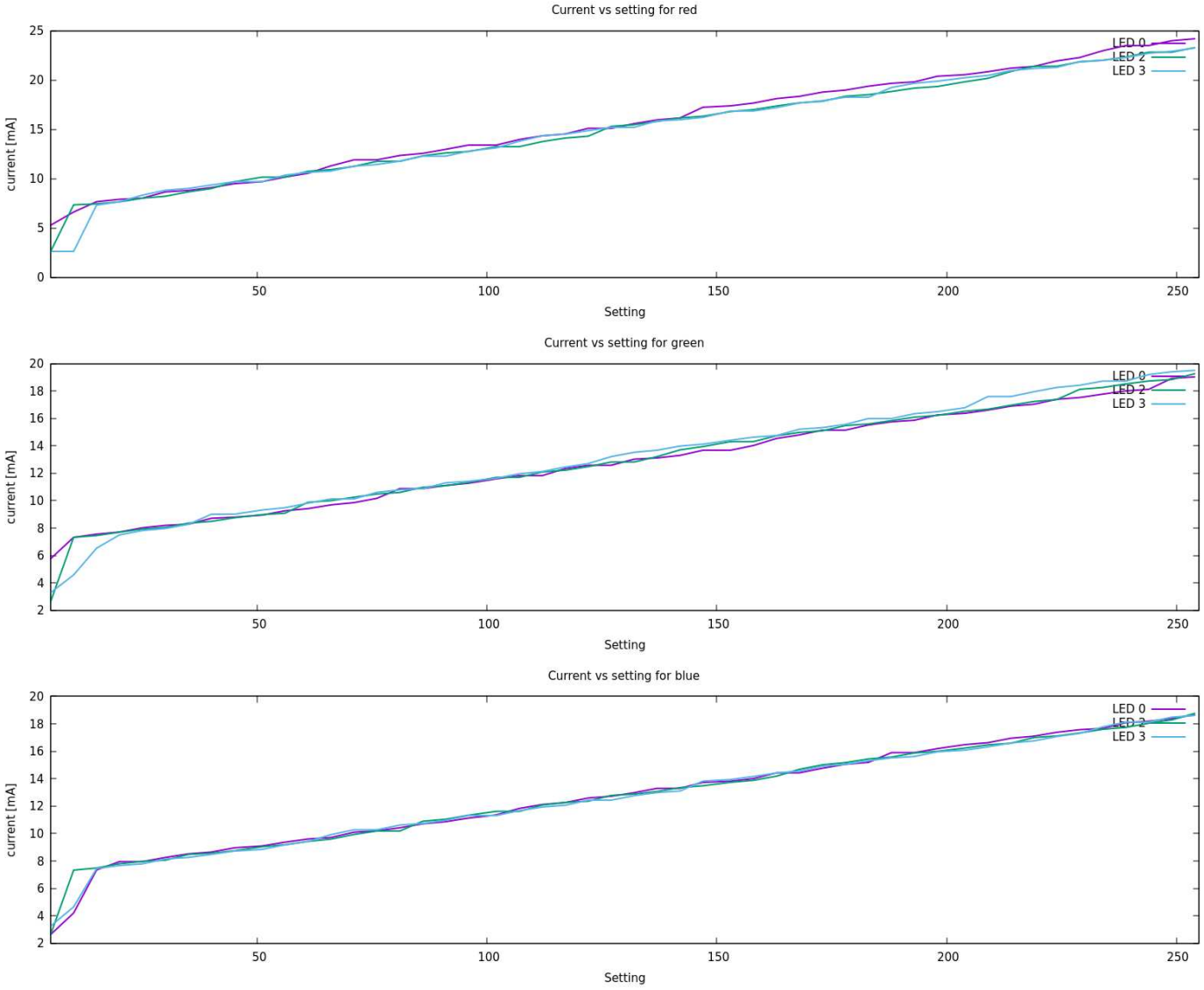
With 8 LEDS white but brightness at 0, we have minimal usage. The other way around–8 LEDs off, but brightness maxed, we are wasting almost 3 times as much.

2 Data

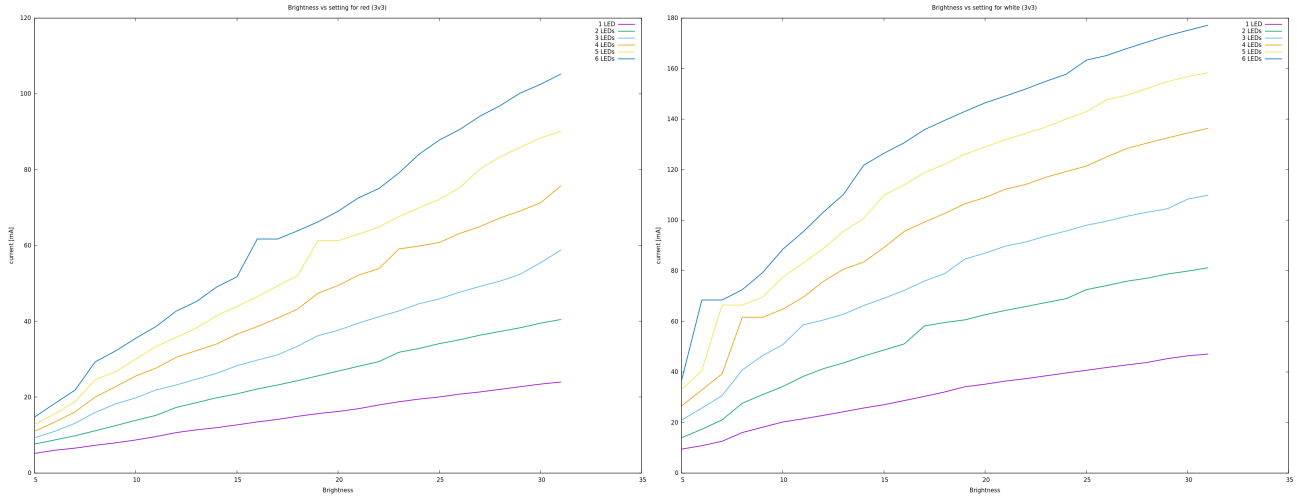
Current consumption vs brightness setting (single LED, colour maxed, 3v3), for each colour. Basically a linear addition, with a bit of overhead:



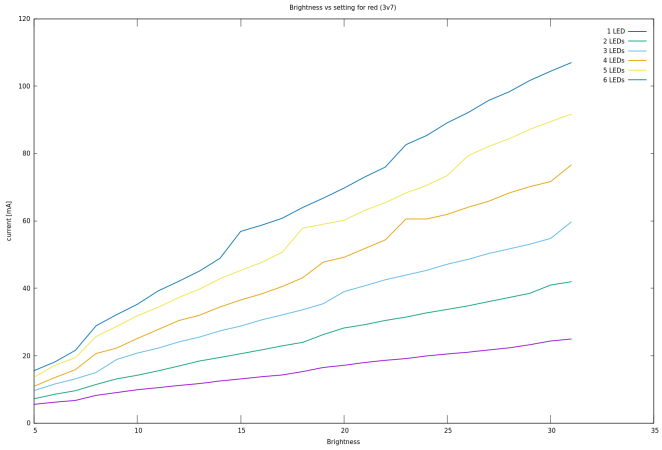
Current vs colour setting value (0-0xff) at full brightness. Nice and flat, inversely proportional to their Vf.

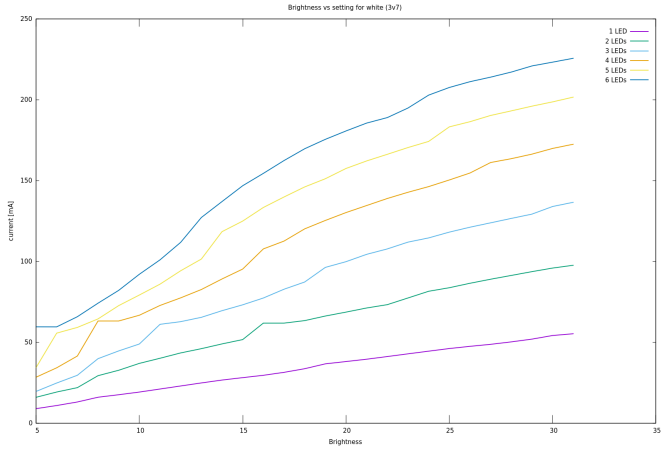


Current consumption for 1-6 LEDs, either full red (0xff, 0, 0) or full white (all 0xff).



This goes up with supply so, as our LiPo lowers, brightness will diminish and so will current draw.





3 Calculations/Estimations and Conclusion

Assuming a worst usage scenario–full brightness, full white, 100% on at 30mA per LED– and 12 LEDs, you should get over 2.5 hours for every 1000mAh you throw at the thing. If you were to stick to a nice turquoise (0, 0xff, 0xff), this goes up to 4 hours per 1000mAh. If you insist on yellow, well we get about 3.3 hours per 1000mAh.

This doesn't account for losses in the cabling, the MCU, etc. But I don't think we need to care.