APA102-2020 64 LED Matrix

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This board contains 64 APA102-2020 RGB LED in 2x2 mm SMD package at an 120 x 120 mil grid. Color and brightness are controlled by 2 wires, serial data and clock. The boards can be chained together with other boards. Only two control pins are necessary to control the LED matrix.

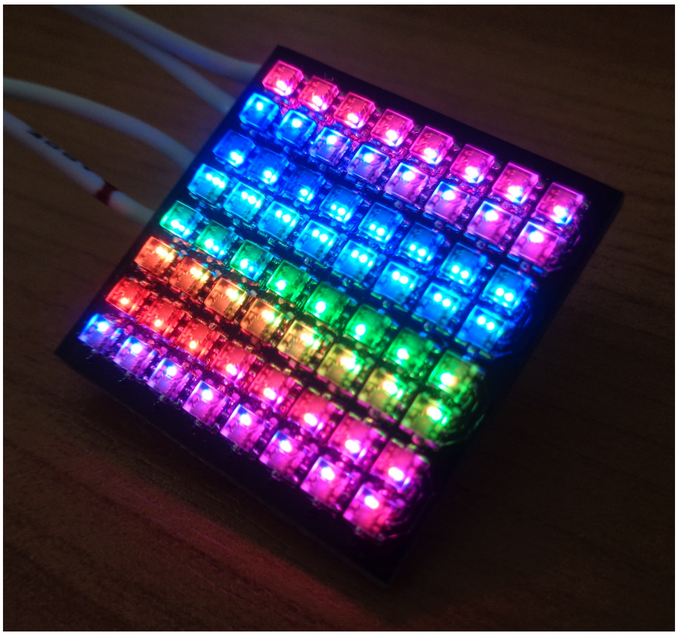

Figure 1: *Photo of the 64 RGB LED matrix board*

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Please feel free to give your highly appreciated feedback, comments and suggestions. Or ask any questions about the board. We'll be glad to answer or help you.

Specification

- Dimension: 1.07 x 1.07 Inch (27.178 x 27.178 mm)
- LED grid 120 x 120 mil (3.048 x 3.048 mm)
- digital control RGB color and brightness of each LED
- 8 Bit color adjustment for each color
- 5 Bit brightness adjustment
- Supply Voltage 4.5V to 7.5V
- worst case power consumption of all 64 LED at full brightness(@ 5V):
  - Red: 6.4 W
  - Green: 3 W
  - Blue: 5.5 W
  - White(RGB): 14 W
- Daisy chain able
- Clock Speed 8 MHz, possibly more
- 473 fps @ 1MHz clock rate

For more details and description about the LED itself, please see the data sheet.

Connection

The board have solder pads on the back side of the PCB. Solder the required wires directly to the pads. The picture below shows the location of the solder pads.

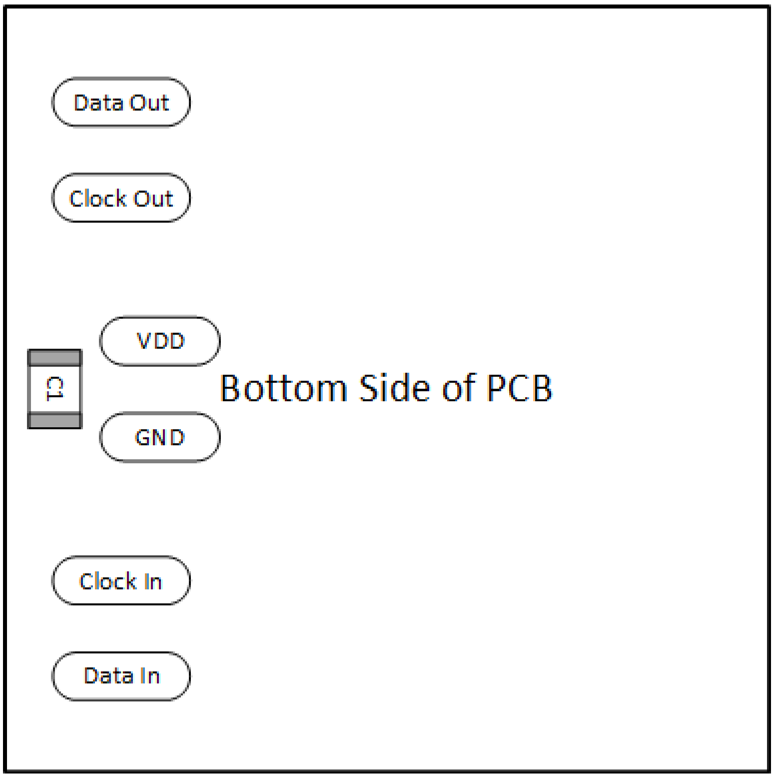


Figure 2: *Position of solder pads*

Power Considerations

The power consumption is variable and depend on the programmed LED pattern, used color and brightness of the LEDs. The board will consume 14 W as a worst case, when all LEDs are continuous on and set to full brightness and full color.

Note: This will overheat the board when continuous on!

A 5V power supply capable of delivering 3A should be used to supply the LED matrix. It is possible and convenient to drive the LED matrix from your controller board, but it's dangerous in the case you program a pattern which draw more current than the controller board can deliver. So it is better to use an appropriate power source all the time.

The following measurements should give you an idea about thermal expectation in relation to the boards power consumption. All measurements was done under the following conditions:

- Room temperature 32 °C
- Power supply voltage 5V
- Temperature measurement at the center of the back side of the PCB
- All 64 LEDs are continuous on

But don't worry too much about the heat rise during software programming. It will take a while to over heat the board, you always have enough time to turn the power supply off. I manage it to melt down a few LEDs in a time of about 20s at full power. ☺

Table 1: *Only red LED on*

Brightness[0...255]	Current[mA]	Power[mW]	Temperature[C]
0	78	390	35.1
1	84	420	37
3	93	465	37.4
7	111	555	38.5
15	152	760	41.5
31	231	1155	47.8
63	389	1945	58
127	697	3485	76.1
255	1280	6400	>80

Table 2: *Only green LED on*

Brightness[0...255]	Current[mA]	Power[mW]	Temperature[C]
0	78	390	35.1
1	83	415	36.1
3	87	435	36.2
7	96	480	36.9
15	111	555	37.7
31	145	725	40.7
63	213	1065	45.4
127	346	1730	55.4
255	603	3015	74.1

Table 3: *Only blue LED on*

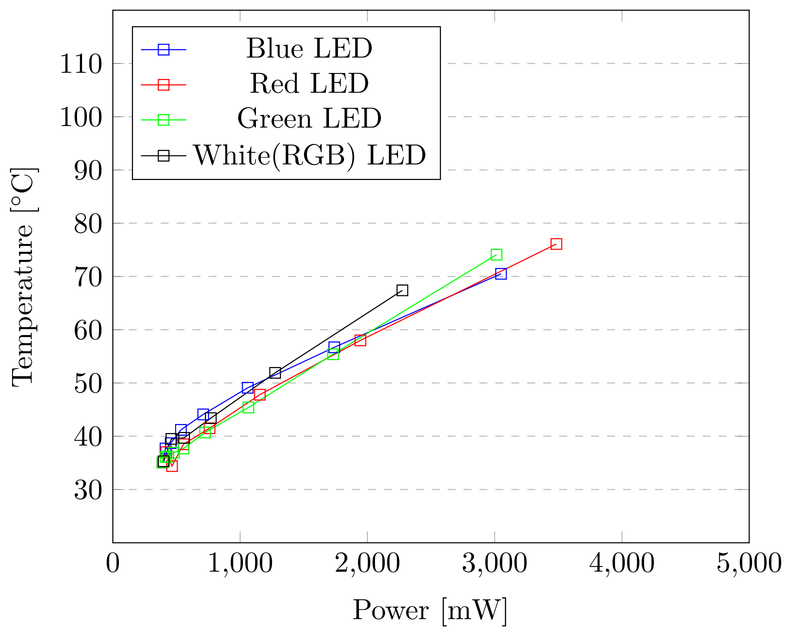
Brightness[0...255]	Current[mA]	Power[mW]	Temperature[C]
0	78	390	35.1
1	83	415	37.7
3	91	455	38.7
7	107	535	41.2
15	142	710	44.1
31	212	1060	49.1
63	348	1740	56.7
127	610	3050	70.5
255	1096	5480	>80

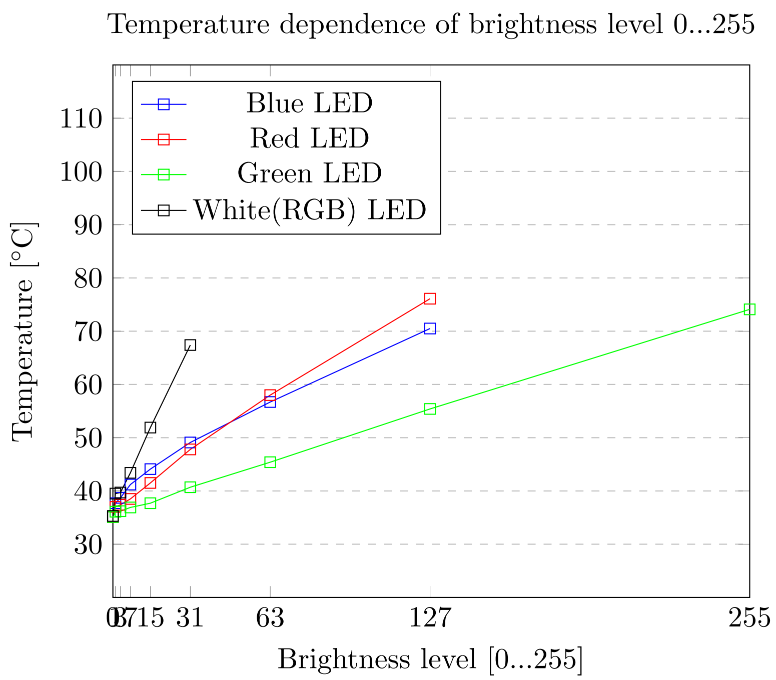
Table 4: *All LEDs (RGB) on: White*

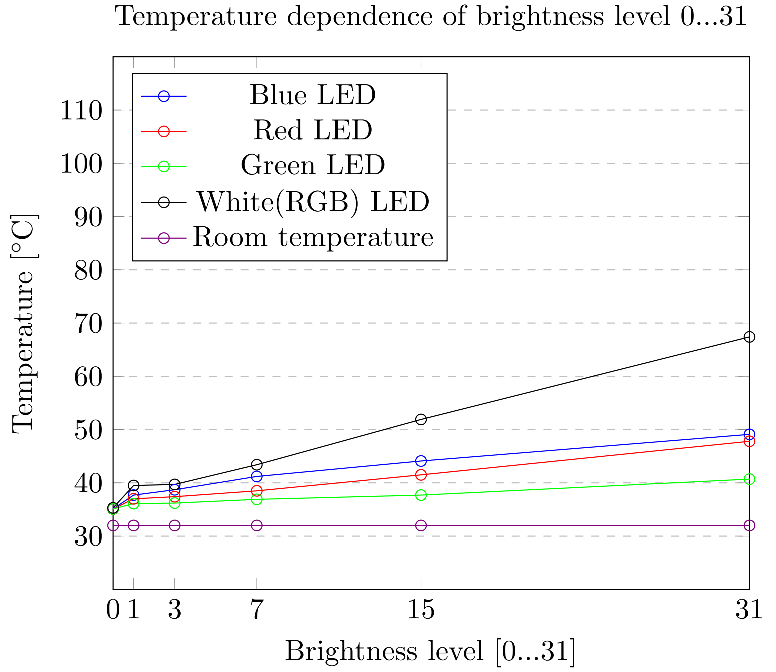
Brightness[0...255]	Current[mA]	Power[mW]	Temperature[C]
0	80	400	35.3
1	92	460	39.5
3	112	560	39.7
7	154	770	43.4
15	255	1275	51.9
31	455	2275	67.4
63	845	4225	>80
127	1570	7850	>80
255	2800	14000	>80

The following graphics show the temperature rise in dependence of the brightness level and therefore power consumption of all LEDs permanently on.

Temperature dependence of power consumtion




Temperature dependence of brightness level 0...255
Blue LED
Red LED
Green LED
White(RGB) LED
Temperature [°C]
110
100
90
80
70
60
50
40
30
0 1 3 7 15 31 63 127 255
Brightness level [0...255]


Temperature dependence of brightness level 0...31
Blue LED
Red LED
Green LED
White(RGB) LED
Room temperature
Temperature [°C]
110
100
90
80
70
60
50
40
30
0 1 3 7 15 31
Brightness level [0...31]

APA102-2020 Daisy Chain

The LEDs are connected in series to a chain of 64 as follow:

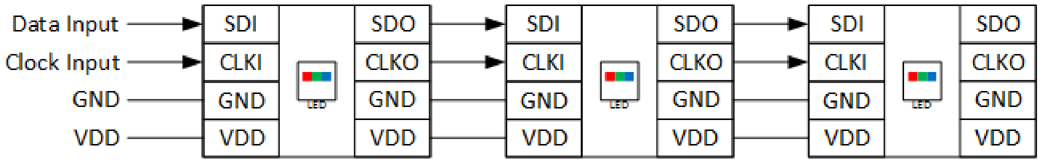


Figure 3: *APA102-2020 Daisy Chain*

The arrangement of the 64 LEDs is like a stripe lay in zick-zack row by row. All LEDs in uneven rows are counted up from left to right. All LEDs in even rows counted up from right to left. The following graphic should help during software programming and controlling the LED matrix.

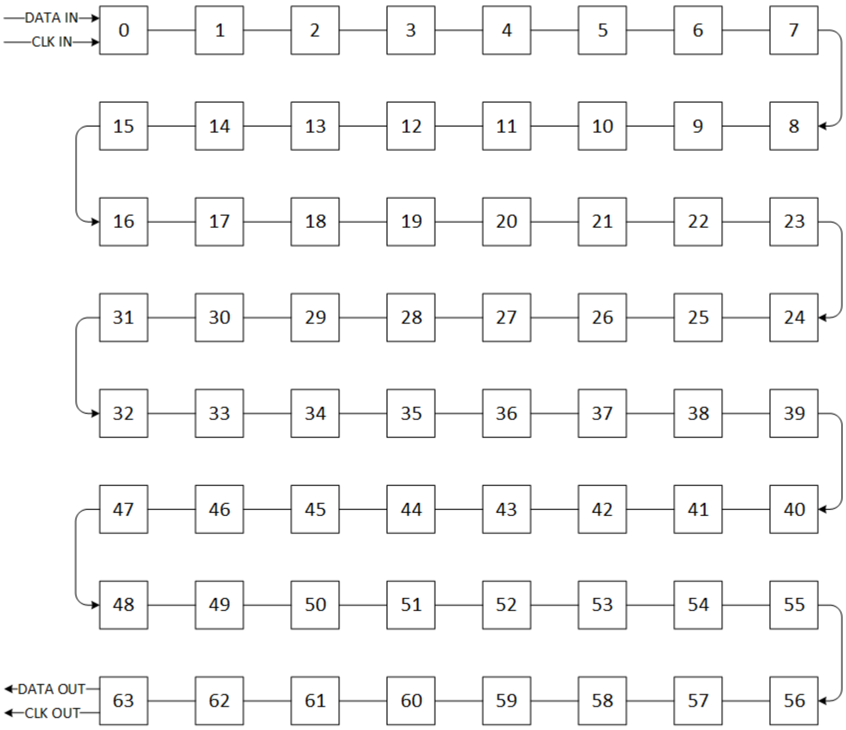


Figure 4: *LED arrangement*

Controling the LEDs - Protocol

The best way to control the LEDs is to use an SPI interface or simply use bit banging.

For Arduino users, there is even a library called ”Fast LED” available.

When using SPI to control the LEDs, then MOSI and SCLK are the only two signals needed.

You need to sent a 32 bit long start frame, followed with the LED frames according to the number of LEDs used and an end frame.

The start frame is 32 bit long and contains only Zeros. The end frame is at least n/2 bit long, where n is the number of LEDs used and contains only Ones. So for up to 64 LEDs it can be 32 bits.

The LED frame must have 3 bits Ones at the beginning, followed with 5 bits for brightness. Then 3x 8 bits color code, blue green and red. The order is always MSB first.

The diagrams below summarize the protocol:

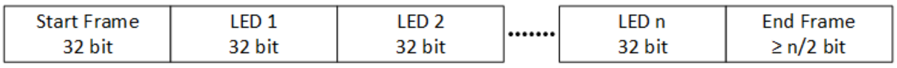


Figure 5: *Protocol Overview*

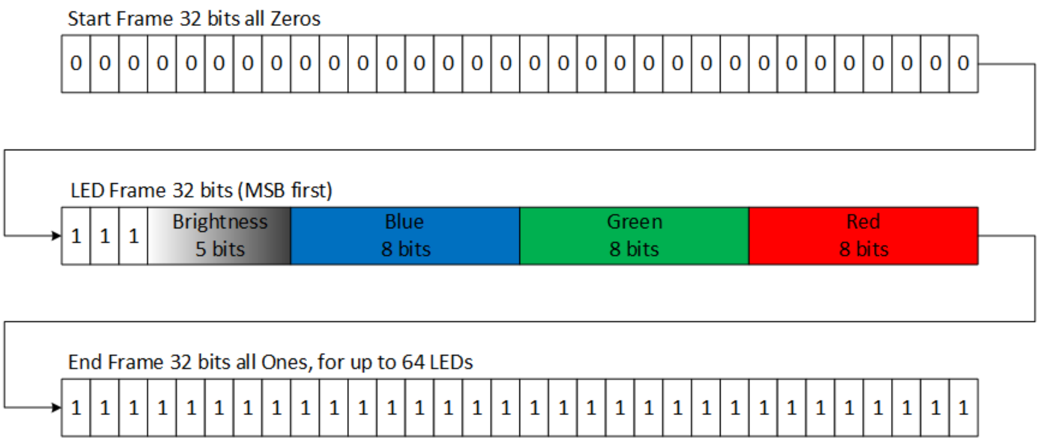


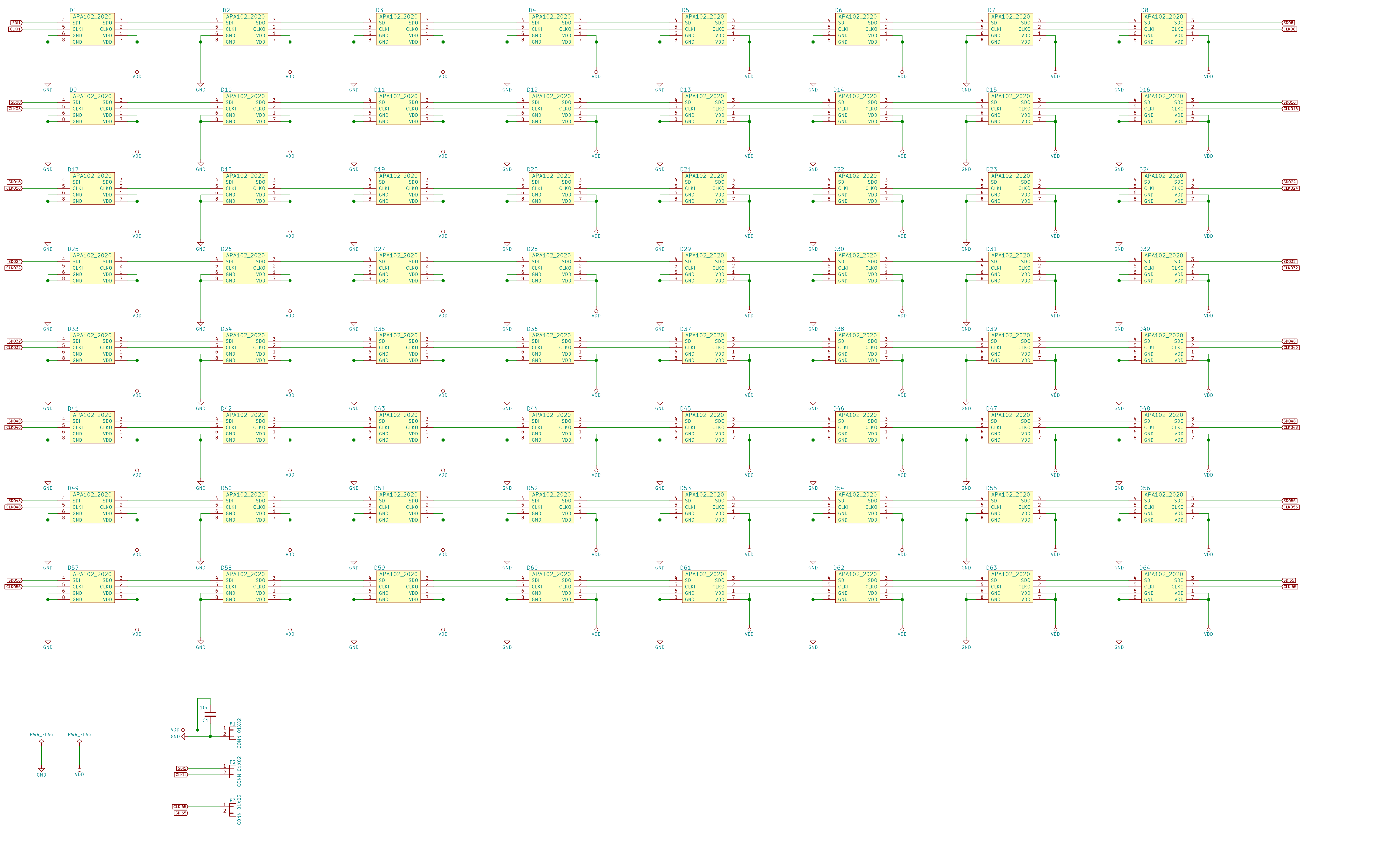
Figure 6: *Frames, LED Frame shown for one LED*

Update Rate

To update one entire matrix, it needs 64 x 32 bit and additional 32 bit for the start frame and 32 bit for the end frame. Totally 2112 bit are necessary to update the matrix. With a clock frequency of 1 MHz you can update the matrix therefore 473 times in a second. Changing the clock frequency will also change the frame rate accordingly.

Attachments

1. Board Schematics
2. CERN OHL v1.2
3. CERN OHL v1.2 How-to-Guide



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Sheet: /
File: APA102_2020_5x10.sch

Title: MLT APA102-2020 8x8 Matrix

Size: A2	Date: 2017-08-09	Rev: 1.0
KiCad E.D.A. kicad 4.0.6		Id: 1/1

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