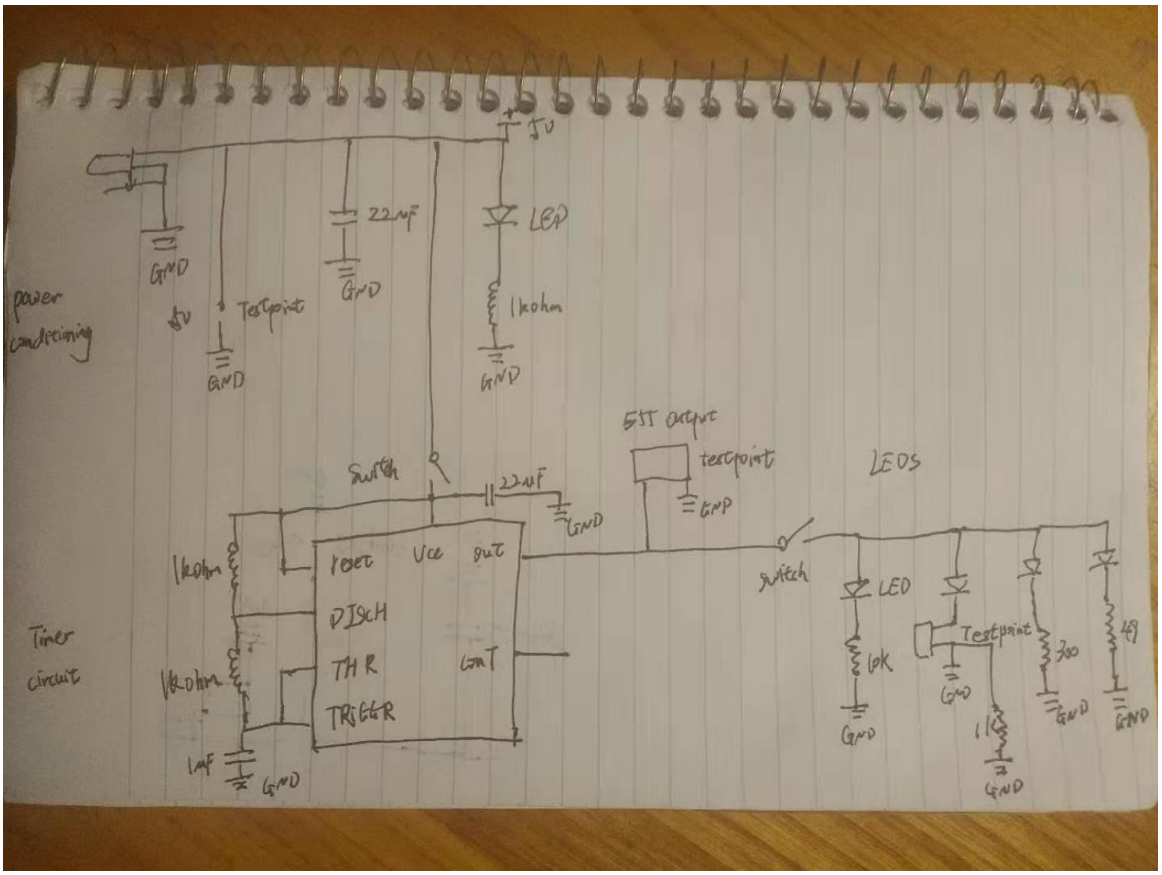
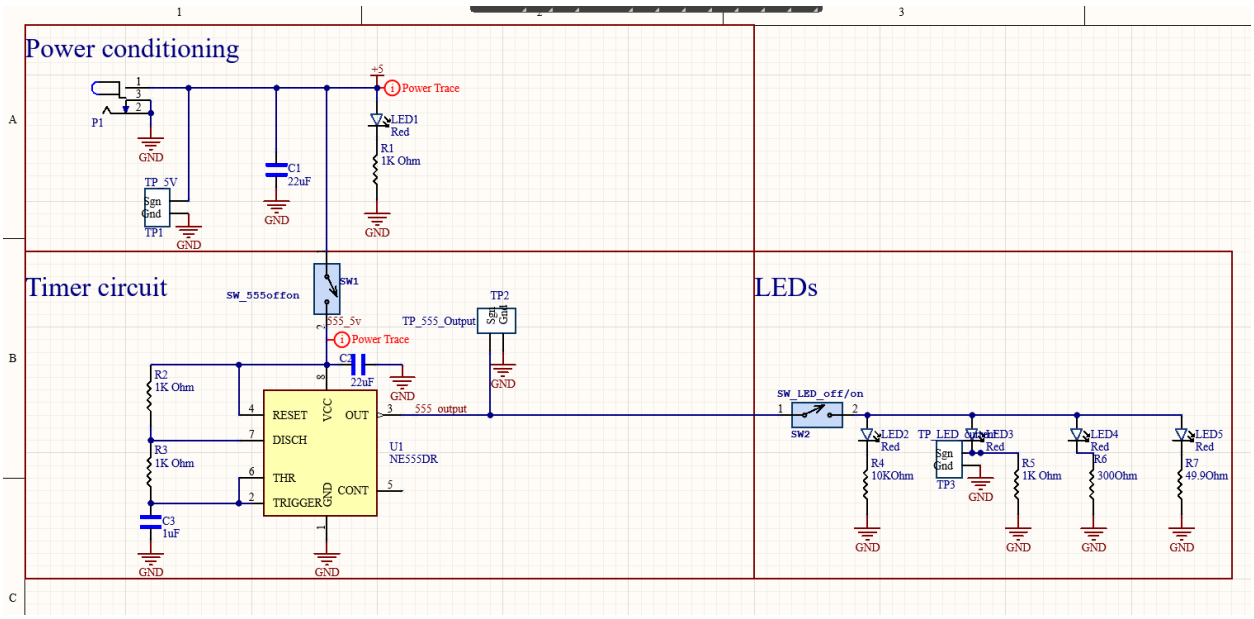
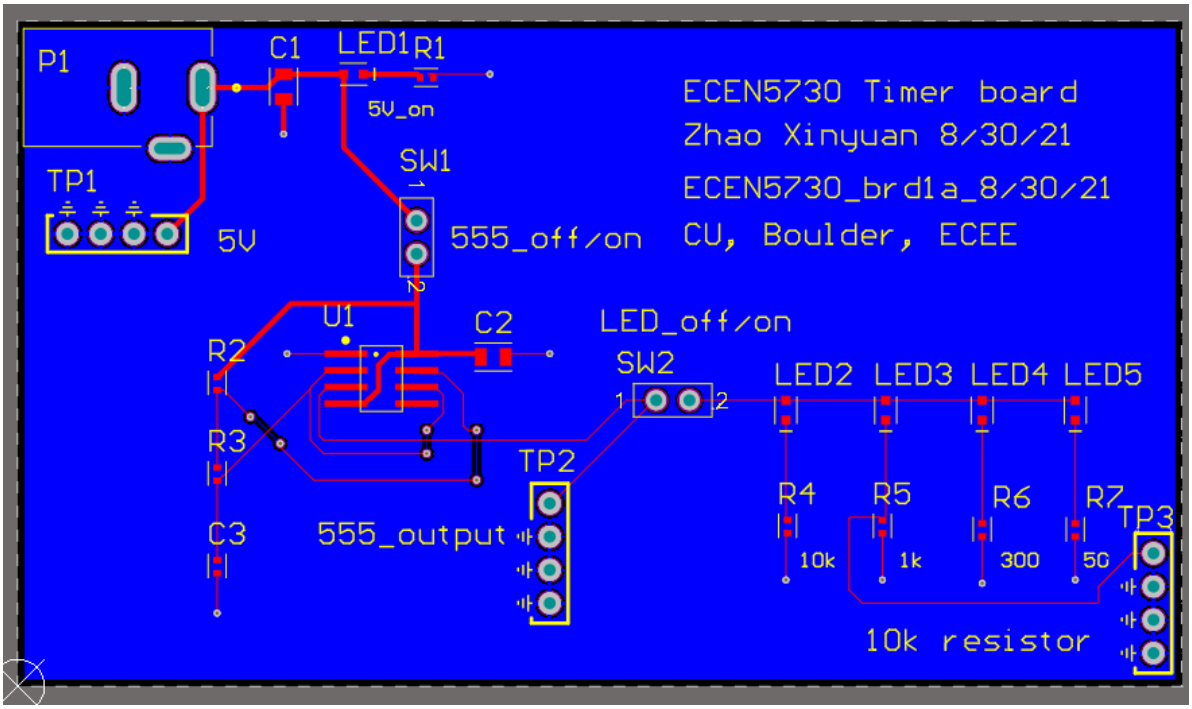
1. Design files and layout:
   (1): Sketch of the schematic started with:



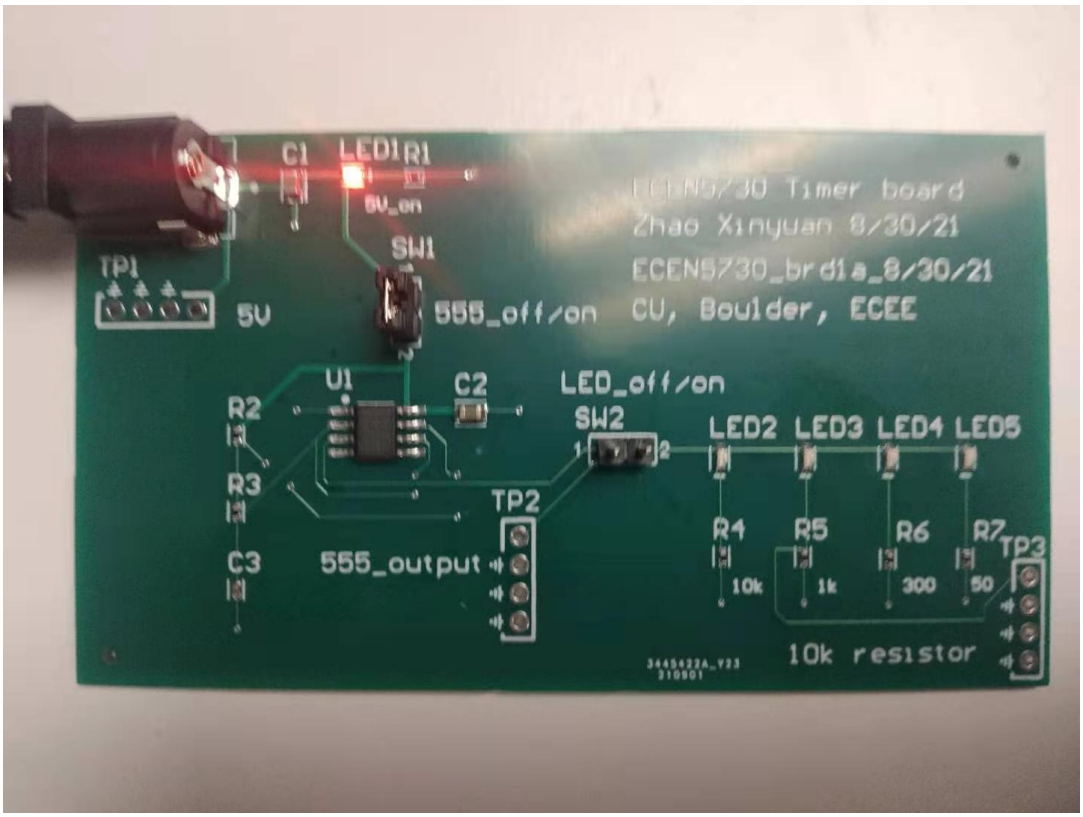
   (2): The actual schematic capture used in Altium Designer



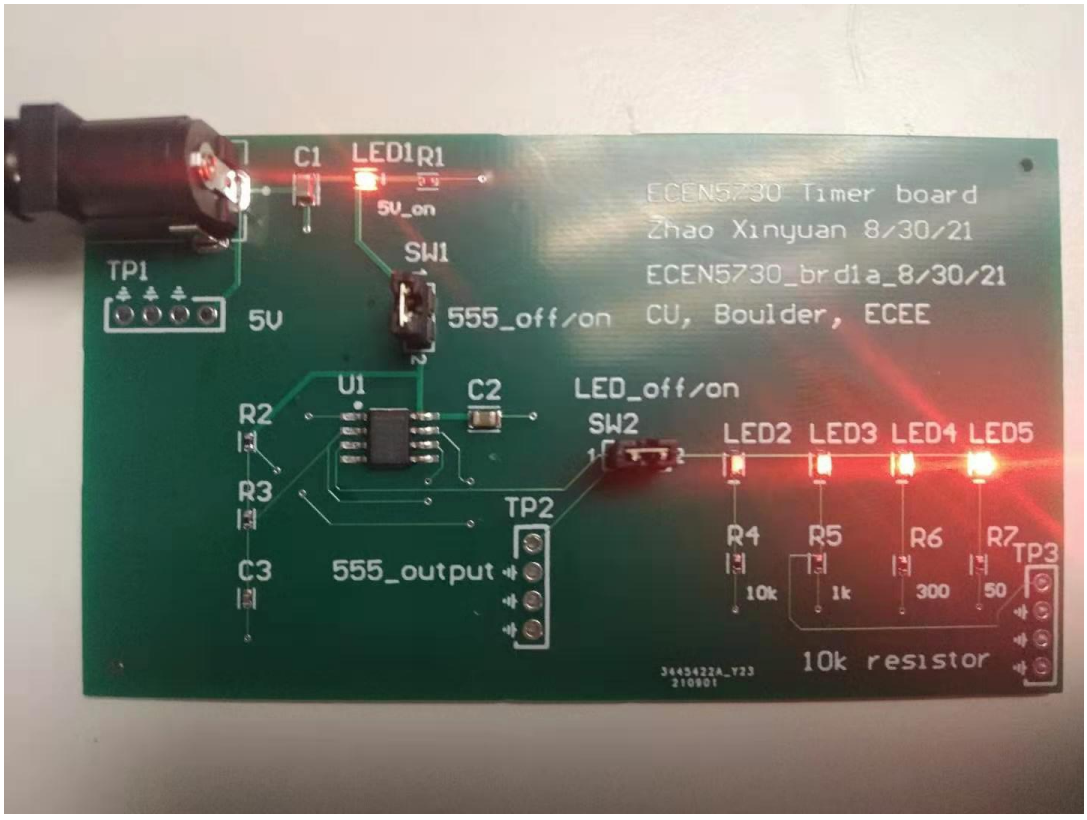
(3): The board layout ended up with



(4): A picture of board with LED indicator of Power ON



(5): A picture of assembled board with lights on of different brightness



2. Engineering specs compared with the performance of the board
(1): The output voltage of the 555 timer, verifying the frequency, duty cycle, with no LEDs connected.

The Frequency read from the scope is 709.62Hz

The duty cycle is calculated as: 922.7us/(1/709.62Hz) = 0.65

The duty cycle is exactly as expected: 65%

The output voltage is 4.65v with open circuit.

(2): The same measurement with all the LEDs connected.

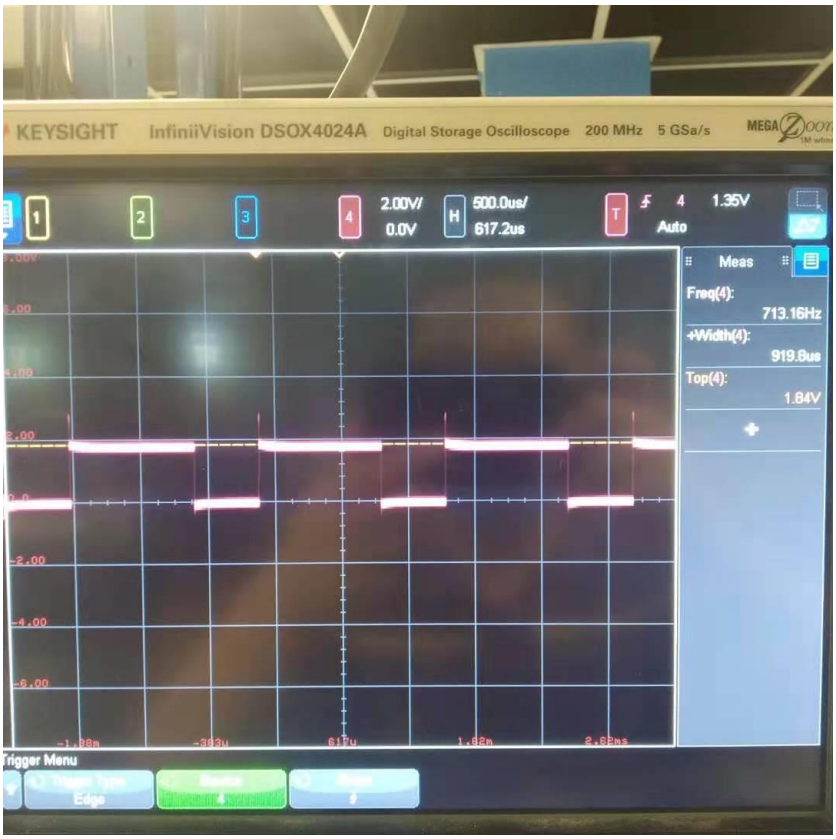
The Frequency read from the scope is 711.91Hz

The duty cycle is calculated as: 921.1us/(1/711.91Hz) = 0.66

The duty cycle is exactly expected as 66%

The output voltage with loaded circuit is 3.65v

(3): The current through one of the LEDs.



The forward drop of the red LED is calculated as 3.65-1.84 = 1.81v

The current through the 1k resistor is calculated as:

1.81v/1k = 1.84mA

(4): Estimate the current through each of the four different LEDs based on the output voltage, the forward drop across the LED and the value of the resistors.

All the LEDs are same red LEDs, so the forward drop is calculated as: 3.65 – 1.84 = 1.81v

The resistor value is given as: 10k ohm, 1k ohm, 300 ohm, 50 ohm.

The current flows through 1k ohm resistor is 1.84mA: The total current is calculated as:

(1000/10000) *1.84 + 1.84 + (1000/300) *1.84 + (1000/50) *1.84 = 45mA

The current through 10k ohm is 0.184mA, the current through 1k ohm is 1.84mA.

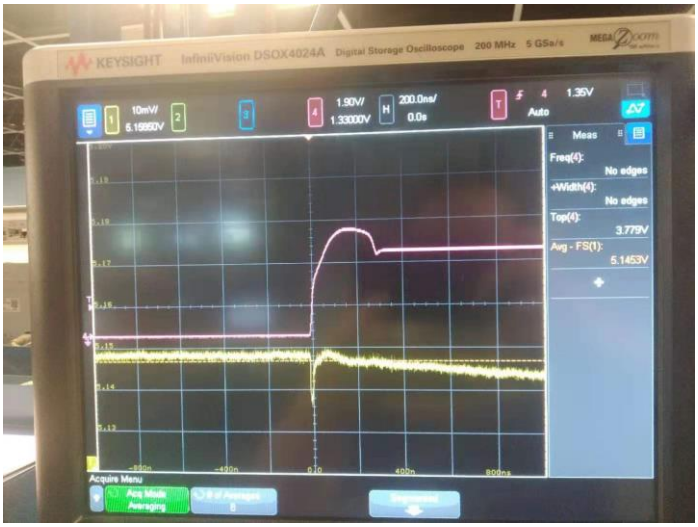
The current through 300 ohm is 6.13mA, the current through 50 ohm is 36.8mA.

(5): What do you estimate the Thevenin output resistance of the 555 timer to be based on the open circuit voltage and the loaded voltage.

Vouput_open = Voutput_load + Rthevenin*I => Rthevenin = (Vouput_open – Voutput_load)/I

= (4.65v – 3.65v)/45mA = 22.2 ohm. The Thevenin resistance is estimated as 22.2 ohm.

(6): The switching noise voltage on the 5 V power rail, synchronous with the 555 switching signal, the rise time of the 555 timer output signal.



From the scope it can be read that the switching noise on 5v power rail is synchronous with 555 output.

The rise time of the 555 output is about 200ns, meets the expection.

(7):Do you have any recommendations on the minimum current through an LED to make it visible as an indicator light? Remember, the duty cycle of the LEDs is only about 70%

The smallest current making the LED visible is the current flowing through the 10k resistor, because it is the output of 555 timer with 66% duty cycle.

The minimum current as an indicator light is calculated as is 0.184mA/0.7 = 0.26mA.

3. Review and conclusion:
   1): There is a font error regarding to the test point of 1k resistor, I put a 10k font on it. If allowing me to redesign it, I will change that.
   2): There is no hard errors with this board, all measurements meet the expectations, and the board works perfectly. There is a soft error regarding with the font.
   3): When connecting the wire around the 555 timers, I made 2 wires through the via. It makes sure the wires around the timer are as short as possible to reduce loop inductance.
   4): To make the board easier to carry and test, I could've tried make the board the size of USB, but it will increase the difficulty of routing.