ECEN 5730 Mid-term Board 1 Report

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Purpose: The purpose of this lab is to design a 555-timer circuit, measure different characteristics of timer output, with and without load, etc.

POR:

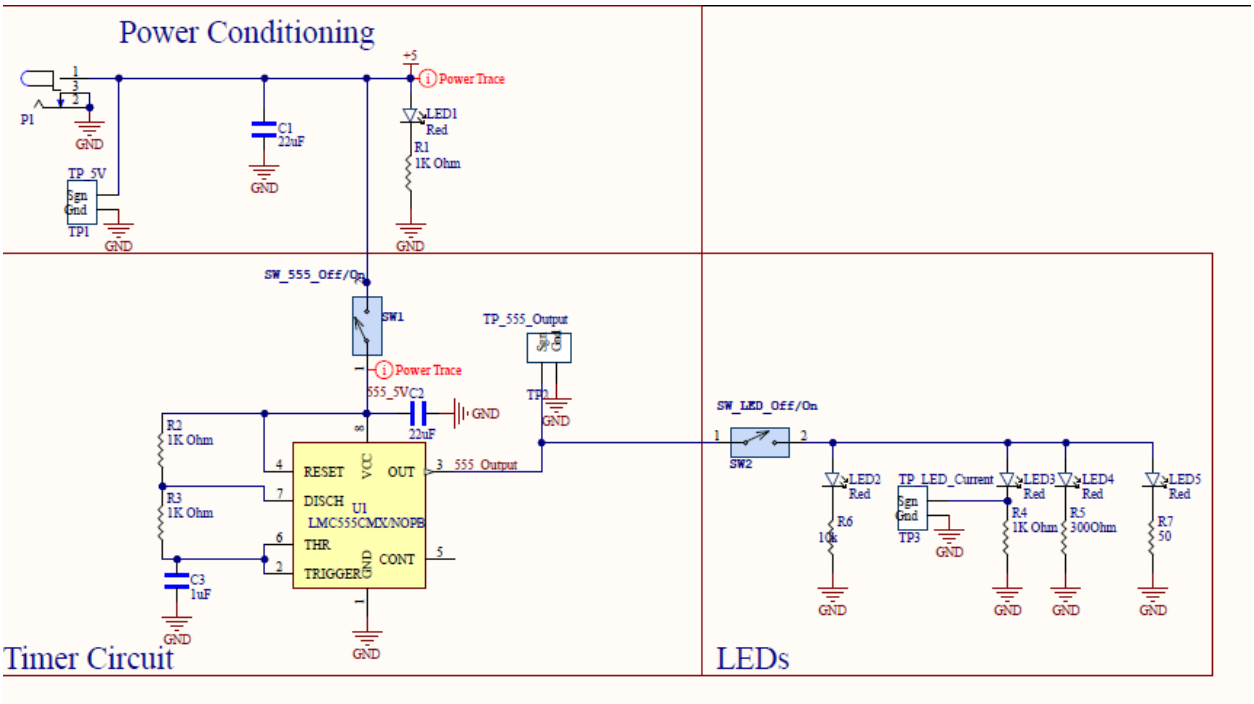
There are certain steps to be followed for developing as per the requirements. (Plan of Record)

1. A power plug is used as an external 5V AC to DC charger to power the board.
2. The 555 timer is designed for about 500Hz frequency and 60% duty cycle.
3. Using parts of JLC integrated library and adding 4 LEDs with series resistors of 10k, 1k, 300 and 50 ohms.
4. To use indicator lights, test points, and appropriate isolation switches
5. Additional test points to measure 5V input rail, the 555-output voltage and current through resistance.

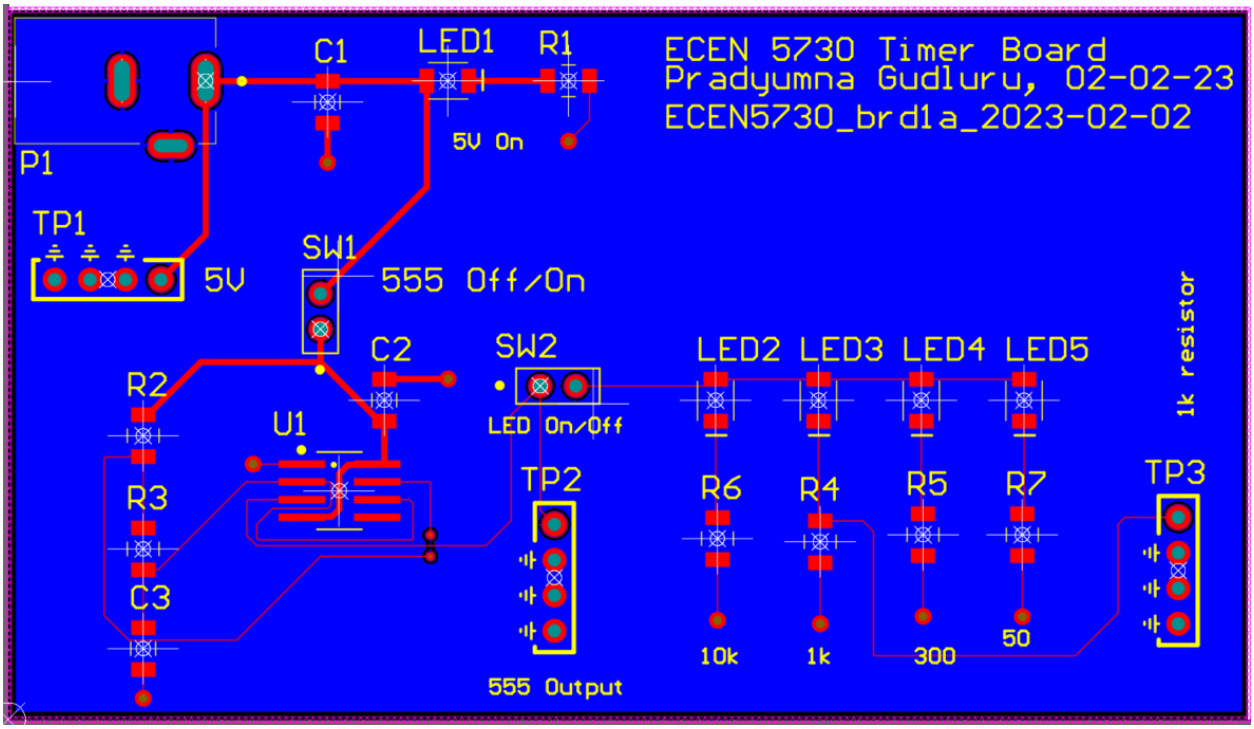
For the board to be in working state,

1. The LED1 turns ON and voltage of 5V is observed at the 5V rail test point.
2. After connecting Vcc to 555 timers, the output through pin 3 should be visible through the second test point.
3. After connecting the LEDs with resistors (Load), the LED's turn ON.

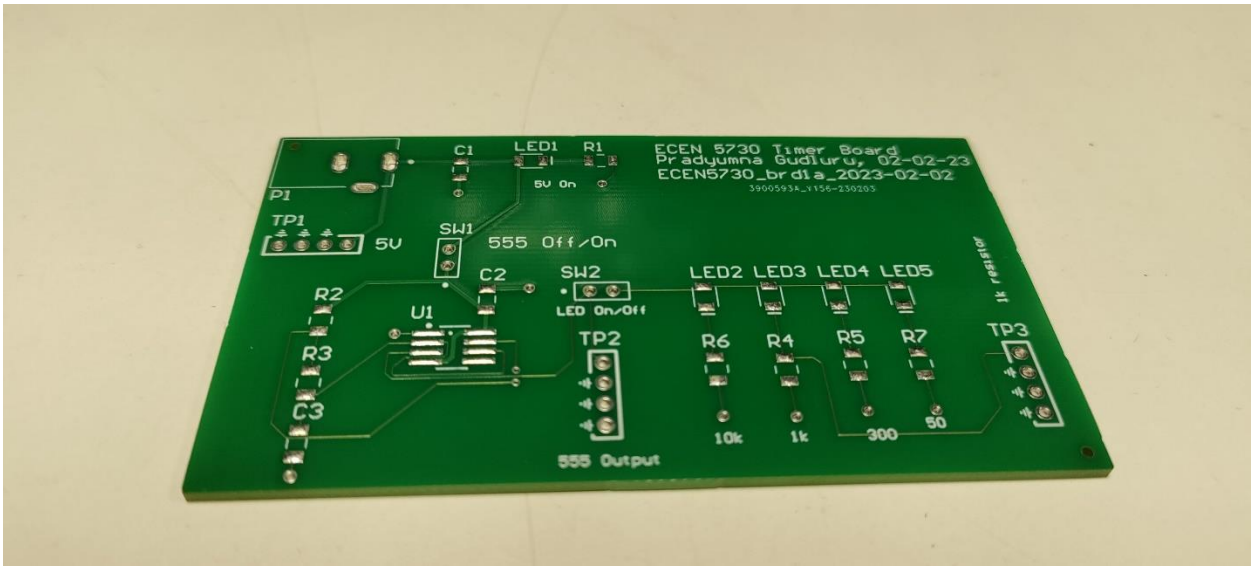
Based on the above requirements, and references provided by professor, the schematic design is as following:



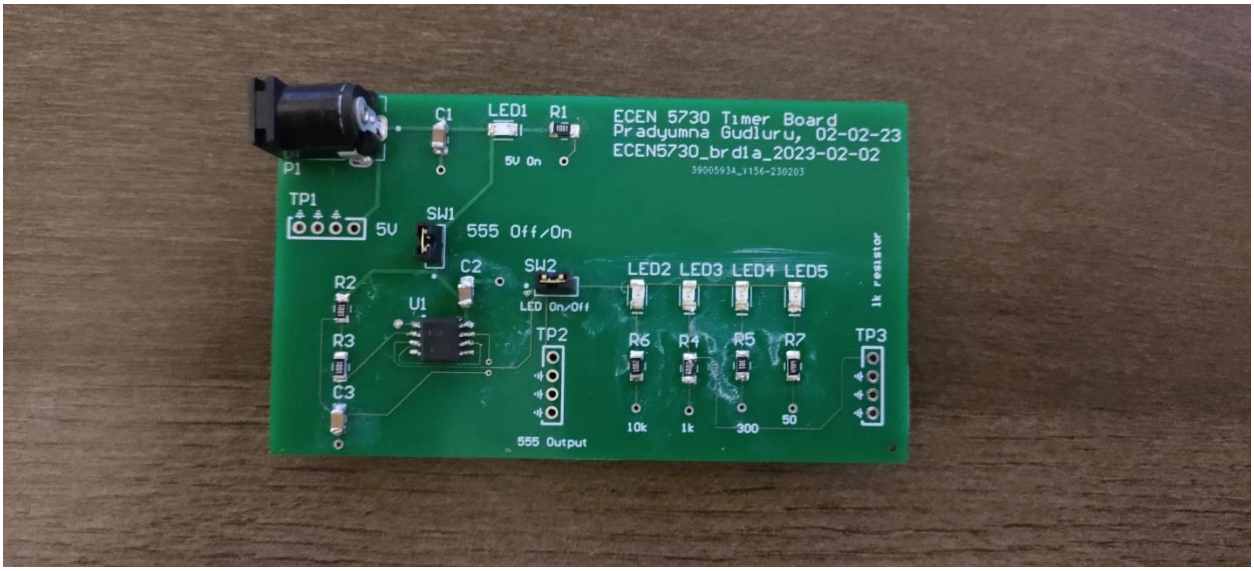
And the following is the layout design of the board,



After getting the general PCB from JLCPCB, it looked like this before soldering:



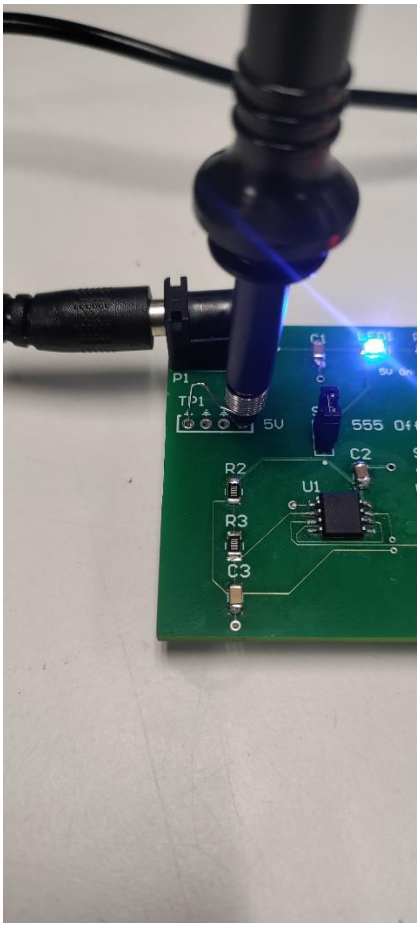
And the board after soldering all the components looks like the following:



The 555 timer IC, the resistors, capacitors and LEDs are soldered according to the designed layout. There are two switches attached to the input of 555 timer (SW1) and the output of 555 timer (SW2). There are three test points provided, one to check for the voltage on the 5V rail (TP1), second to test the output at the 555-timer (TP2), and the third test point to calculate the current passing through the 1k resistance.

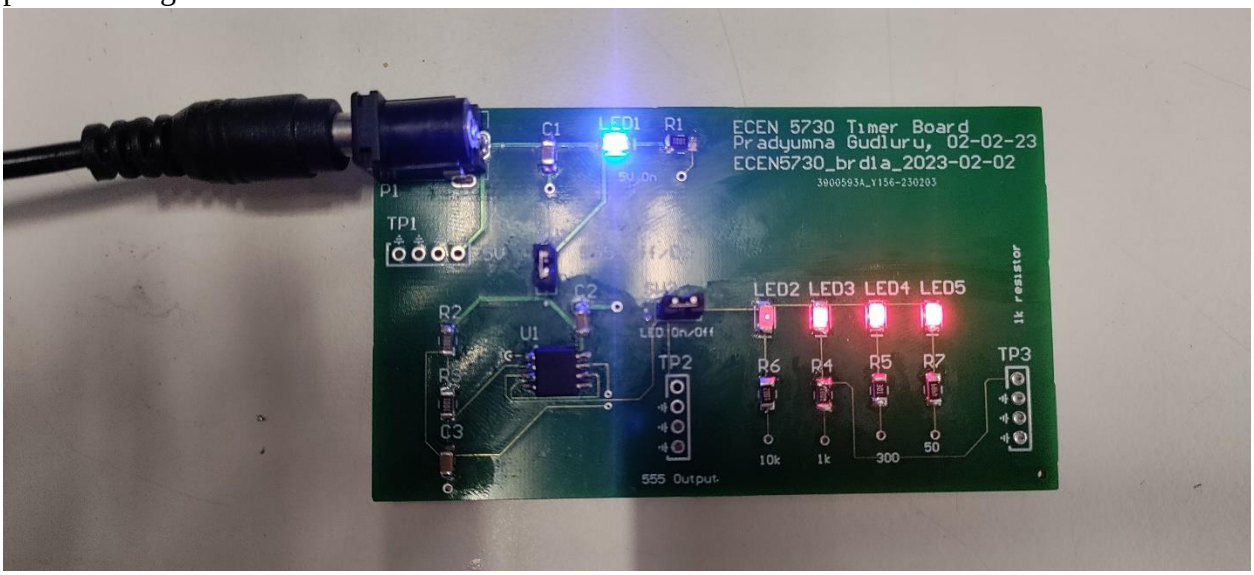
For checking if the 5V rail is working, the flag on SW1 is removed. The following are the screenshots.

The above screenshot shows the voltage on the Oscilloscope when checked at test point 1 (TP1) for the 5V rail.

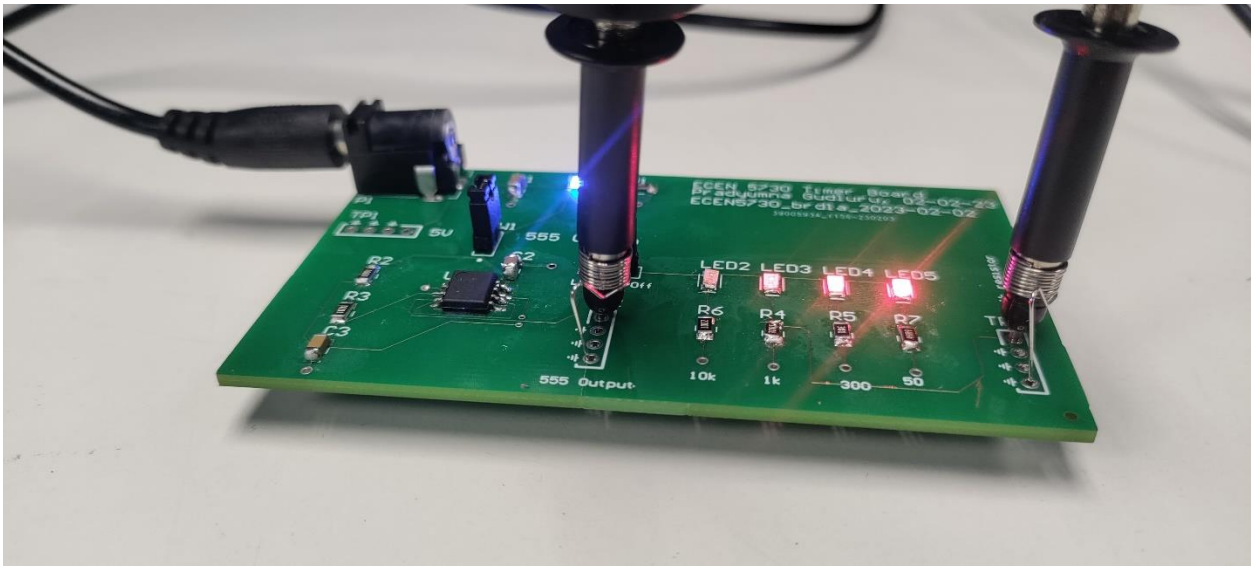


The above image shows the setup of the probe and the LED1 glowing in Blue color as soon as the power is connected.

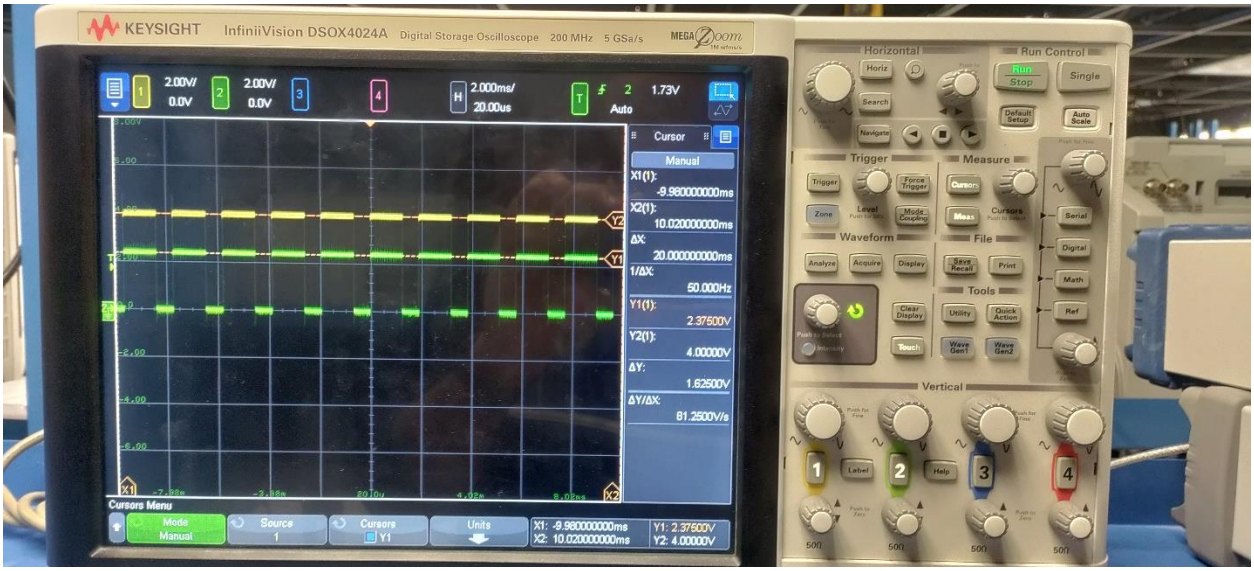
When SW1 was switched ON, the 555 timer got to working condition, providing an output of 5V through the O/P pin 3. When the SW2 is connected the LEDs are switched ON and the current passes through the load.



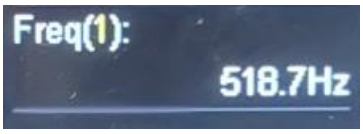
For measuring the voltages at the other two test points, probes are connected as per the below image.



The measurement at the TP2 is Channel 1 with yellow on oscilloscope and TP3 is channel 2 with green on the oscilloscope.



When there is no load connected (SW 2 open), the 555-timer output voltage was around 5V as mentioned above. Once the switches were closed, the voltage measured due to the load dropped to 4V as visible on the Y2 cursor on the above image. The yellow square wave shows the output voltage of the 555 timers (TP2).



The frequency obtained from the board is 518.7Hz.

Current Calculation:

The voltage checked at the TP3 is 2.375V.

For the current passing through the resistors:

10k: 2.375/10k = 0.2375mA

1k: 2.375/1k = 2.375mA

300Ohms: 2.375/ 300 = 7.916mA

50 Ohms: 2.375/ 50 = 47.5mA

For this circuit, the 7.916mA is a good amount of current passing through the load. Hence, 300 Ohms is a recommended load resistance.

Thevenin Resistance:

For the Thevenin resistance, we calculate using the voltage drop due to connecting the load (SW 2 OFF to SW 2 ON).

There is a drop of 4.97V to 4.00V, when there is a load connected. Hence, the equivalent output resistance is given by,

$R_L = 4/ (0.2375 + 2.375 + 7.916 + 47.5)*10^{-3} = 68.93$ Ohms

$R_{th} = ((V_{th} – V_L)/V_L)*R_L = ((4.97 – 4)/4)*68.93 = 16.71$ Ohms approximately 16 Ohms.

Conclusion/ Observations:

While connecting the board and testing it, there were no hard errors identified, and the board is functioning as per the working state. The LEDs were switched ON as per the requirement, on the 5V rail and the output load of 555 timer circuit. The noise was nearly small. The rise time is around 60.63ns with load connected to the circuit and 94.35ns with load disconnected from the circuit. The fall time is 54.37ns with load connected to the circuit and 27.64ns with load disconnected from the circuit.

By using the best practices, like using 10x probes after testing through compensation signals, using spring tips for reduced loop inductance while measuring, using solder flux and pointed soldering edge while soldering, etc. the board got working providing really good results.

The lessons I have learnt form the design and bring up of this board are, while designing the schematic, one must take decent care on connecting the wires with other components as they may be seen connected from zoomed out window and add good number of netlabels to be clear while doing the layout. On the layout file, one must take good care in setting up the ground plane with minimum number of cross-under. If space is available while designing the layout, it is always better to have a good number of test points to analyze the circuit for minute details.

References:

1. Lab manual provided by Prof. Eric Bogatin
2. https://sites.google.com/colorado.edu/practicalpcbdesignmanufacture/erics-altium-workshop