Brd1 report

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ECEN5730

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**Introduction**:

Brd1 is a PCB consisting of a simple 555 timer circuit with its output connected to several leds connected in parallel. This board was the second PCB constructed in ECEN5730 and served to practice the fundamentals of PCB design. The board is split into three blocks, the power block, the timer block, and the indicator block. This report will also be split into three blocks, where the design process for each block will be covered, along with a section which summarizes the entire design process.

**Equipment/components:**

1x Power Barrel Connector Jack 2.10mm ID (0.083"), 5.50mm OD (0.217") Through Hole, Right Angle

2x2Pin switch

1x 555 Type, Timer/Oscillator \_Single\_ IC 3MHz 8-SO

4x CHIP RESISTOR - SURFACE MOUNT 1KOHMS ±1% 1/4W 1206 ROHS

1x CHIP RESISTOR - SURFACE MOUNT 10 KOHMS ±1% 1/4W 1206 ROHS

1x CHIP RESISTOR - SURFACE MOUNT 300OHMS ±1% 1/4W 1206 ROHS

1x CHIP RESISTOR - SURFACE MOUNT 30OHMS ±1% 1/4W 1206 ROHS

1x22uF ±10% 25V X5R 1206 Multilayer Ceramic Capacitors MLCC - SMD/SMT RoHS

1x1uF ±10% 25V X5R 1206 Multilayer Ceramic Capacitors MLCC - SMD/SMT RoHS

4xRed 621~631nm 1206 Light Emitting Diodes (LED) RoHS

**General expectations of board:**

For this board to be successful, the power block needs to output 5 volts, and the led indicator on the power block needs to be active. In the 555-timer block, when unloaded the timer needs to output a 5v signal at 500hz, with a duty cycle of 60%. Some tolerance in these values will be acceptable since this is a simple practice board.

**Overall design(sketch):**

**A diagram of a circuit

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**Overall schematic:**A diagram of a circuit

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**Overall component placement:**

A blue circuit board with red and white lines

Description automatically generated

**Power block:**

The power block features a 22uf capacitor which is designed to reduce noise onboard. Moreover, there is a red LED indicator which indicates if the board is being powered properly. The circular symbol at the top right of the circuit is a parameter set which allows designers to transfer the properties of one electrical net to another electrical net, simply by adding another parameter set symbol to said net. The settings used by the power net are later re-used on a net present on the timer block.

A diagram of a circuit

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A computer screen shot of a circuit board

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While routing the traces for the PCB, thicker traces were used for lines intended to carry power. These are about 20 millimeters in diameter and are larger in size to accommodate the larger currents expected of powerlines. A Test point is also present in the circuit, the component labeled TP1 is an opening in the circuit which will allow oscilloscope probes to read the voltage delivered by the power jack.

**Timer block:**

**A diagram of a circuit board

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(Altium schematic)

**A blue screen with red and yellow lines and numbers

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A blue screen with red and yellow lines and numbers

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(Board routing utilizing vias)

To reduce the overall length of the wires in the board, and therefore signal noise, a via was placed in the indicated position and a signal was routed to another via on the copper pour layer of the board. This allowed a connection to be made underneath the output to switch connection, with minimal interconnect length.

**Indicator block:**

**A diagram of a circuit

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(Altium schematic)

A blue screen with red and yellow lights

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(Altium design)

**Testing:**

All blocks feature a switch which allows for output signals of each block to be disconnected from the input signals of their destination block.

**Produced board:**

A green circuit board with white text

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**Assembly:**

A green circuit board with red lights and black wire

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(fully assembled brd1)

Each block is grouped together on the board as seen above. An easy way to distinguish each block is to look for where the board is separated through switches.

It would appear that the best led configuration for indication occurs with led 2, or on r6. Later in this report the amount of current flowing through r6 is calculated, which should be the amount of current used in later designs when attempting implement led indicators.

**Testing**

A screen shot of a computer

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(Output voltage of 555 timer block)

Here is the waveform measured through the test-point for the timer block. Testing occurred in two phases, one with the switch connecting the led indicator block active, and another with the switch inactive.

With the leds active, there were no noticeable differences in the frequency or the rise time of the circuit.

The measurements were collected with a 10x probe, the calculations and excel data account for this.

A graph with numbers and a yellow line

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(recorded characteristics of 555 output signal with no leds connected)

A yellow line on a white sheet

Description automatically generated

(recorded characteristics of 555 output signal with leds connected)

In the next section, the current through the resistors was determined by finding the voltage being outputted from the timer block, and then comparing that with the voltage found on r5. The measurements found were recording using a 10x scope probe, and after comparing the two voltages it was found that the leds feature a 0.6v forward drop. By Dividing the voltage outputted from the timer by the resistance of each branch in the indicator block, the current through each branch could be determined. This information can be used to get an idea of how much current an led branch should be designed to process, so that it is bright enough to indicate power and not too bright that it hurts to look at, or wastes power.

A screenshot of a computer

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(current through resistors in indicator block)

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Description automatically generated

(Max current through resistor r5)

A white sheet with black text and numbers

Description automatically generated

(max current through resistor r4 )

A white grid with black numbers and black text

Description automatically generated

(Max current through resistor r6)

A graph with numbers and text

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(Max current through resistor r7)

**Switching noise:**

A screen shot of a graph

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(switching noise on the 5v powerline vs 555 timer output)

In the image above you can see an example of the impact of switching noise on the circuit. Since there is a decoupling capacitor, the effect of switching noise doesn’t seem to be too large in this circuit. It appears that the noise ranges from 518mv to 521mv. This information could be used to get a general idea of how far certain signals should be from the power block during the design process.

**Thevenin resistance:**

The unloaded voltage recorded on the output was approximately 5 volts, which when connected to the indicator block this was reduced to 4 volts, from this the value of rth in the 555 timer can be estimated with the following math:

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Description automatically generated

**General analysis:**

There were a few things that worked well in this board and a few that didn’t. For instance, during the creation of the Altium circuit layout, a connection from ground to the trigger pin was somehow deleted. This led to issues in generating the proper frequency after the board had been assembled. The remedy to this issue was to apply some solder from the capacitor located on the trigger pin to the disconnected via. Other than that issue, the board’s design and assembly proceeded without issue.

**Conclusion**

During the design of this circuit, many concepts were covered, such as general PCB design principles, surface mount soldering techniques, pcb ordering procedures, and many more. This lab also served as a means to determine an appropriate amount of current for any led indicators. This lab was highly informative and will serve as an example for future labs.