Random Number Generator

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Project Summary

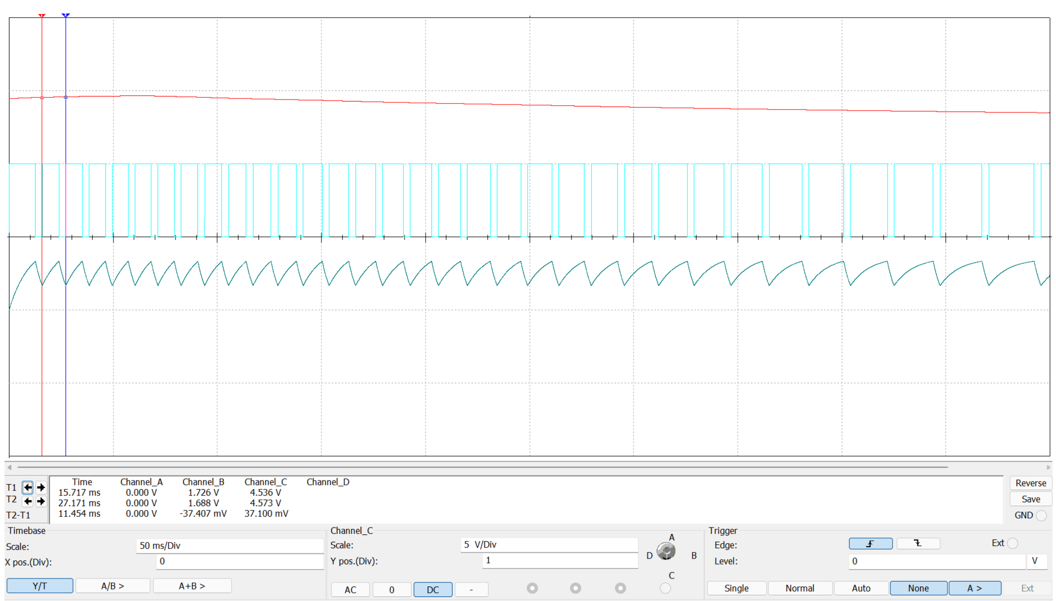
After learning about sequential and combinational logic, we were challenged to make a random number generator (RNG) that “rolls” a die and outputs a number from 1-6 based on the roll. This project combined our knowledge of capacitors, 555 timers, D flip-flops worked, boolean logic, and simple electrical components to complete our final project.

Analog Section

In the first procedure (the analog section), a capacitor (C1) will charge through the 1.8 kΩ resistor when the button is being pressed; as long as the button is being pressed, the dice will be “rolling:” in other words, the capacitor will continue charging and there will be a constant power source to the rolling circuit. When you release the button, the circuit loses that power source and simplifies, in which C1 becomes the power source. Since C1 has a limited storage capacity, the circuit “slows down” (i.e. the oscillation period becomes larger) and eventually settles on a “random” value once the oscillation stops. In effect, this portion of the circuit produces a dampened square wave that slows down over time, simulating a dice roll.

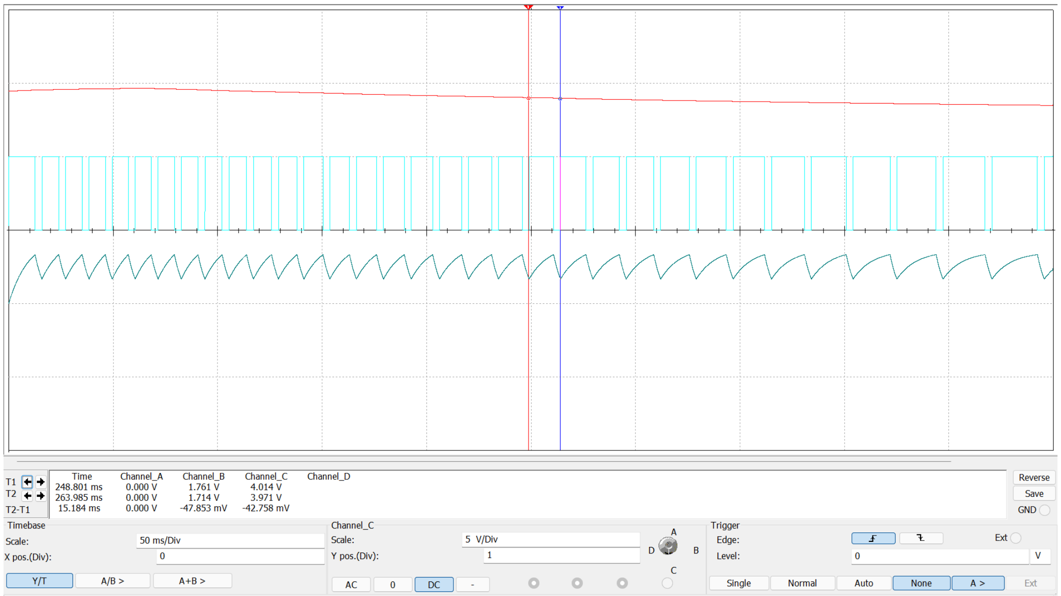
Oscilloscope Measurements

When Pressing Button



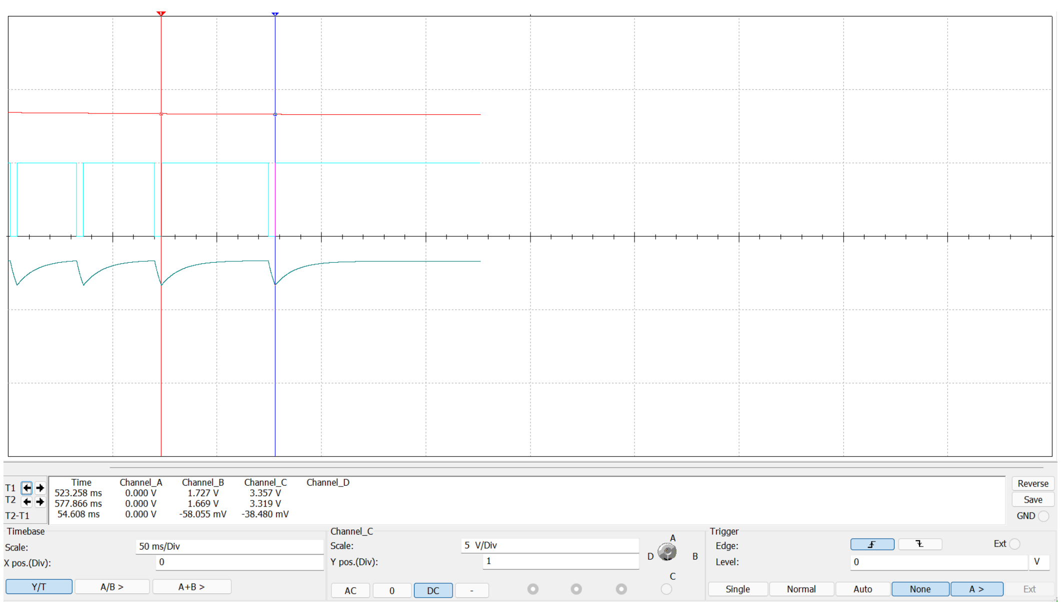
$$f = \frac{1}{27.151 - 15.717} = 87.306\ Hz$$

Shortly After Releasing Button



$$f = \frac{1}{263.985 - 248.801} = 65.859\ Hz$$

Slightly Before Oscillation Stops



$$f = \frac{1}{577.866 - 523.258} = 18.312\ Hz$$

Sequential Logic Section

In the second procedure (the sequential logic section, or the counter section), we use a series of frequency dividers using DFFs to make a counter from 1 to 6. We set the counter to initially be 1 at the start of the circuit, then count up to 6 before resetting the counter to 1 after it reaches 7 (i.e. once it reaches 7, we detect that and reset the counter to 1 using boolean algebra). Below is a table displaying all possible output combinations (not including 7 since it changes back to 1 asynchronously from the clock):

Combination Chart

Clock Cycle	A (2^2)	B (2^1)	C (2^0)	N_{10}
0	0	0	1	1
1	0	1	0	2
2	0	1	1	3
3	1	0	0	4
4	1	0	1	5
5	1	1	0	6
6	0	0	1	1
…	…	…	…	…

Combinational Logic Section

In the third and final section of the circuit (the combinational logic or decoding section), we decoded the binary value of the counter and displayed them on a seven-dot display to reflect the appearance of a real die. To do this, we created a truth table that included all possible display combinations and then utilized our knowledge of boolean algebra to transform those values into outputs that matched the results of our truth table (note: we only coded for 1-6 since we knew neither 0 nor 7 would be displayed to the end user).

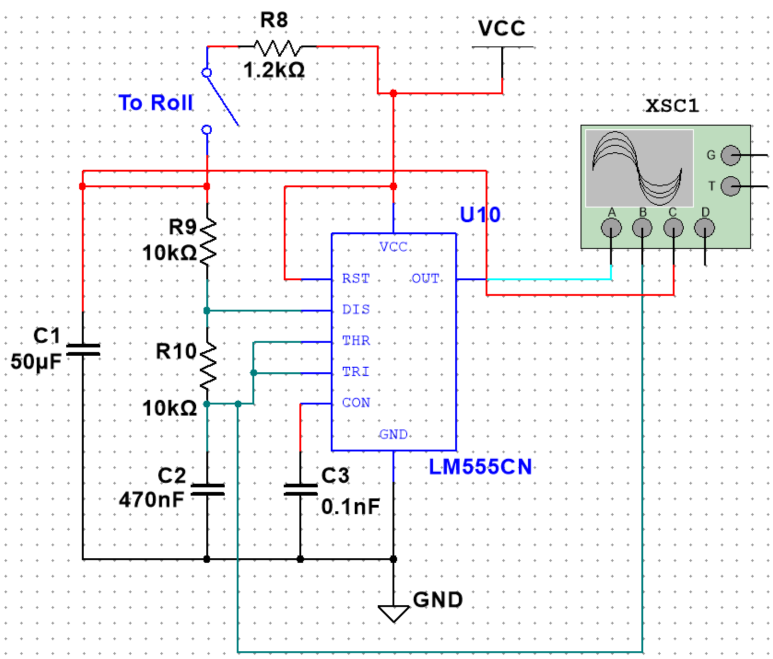
Truth Table

A	B	C	TL	ML	BL	MM	TR	MR	BR
0	0	1	0	0	0	1	0	0	0
0	1	0	0	0	1	0	0	0	1
0	1	1	1	0	0	1	1	0	0
1	0	0	1	0	1	0	1	0	1
1	0	1	1	0	1	1	1	0	1
1	1	0	1	1	1	0	1	1	1

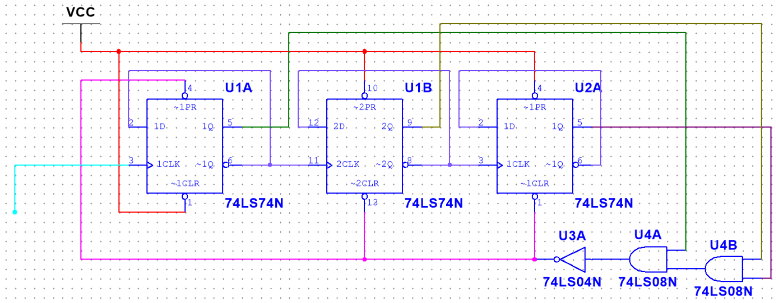
Circuit Schematics

Below are each of the three circuits we created in isolation, followed by a final complete circuit schematic and an accompanied video of the randomization process.

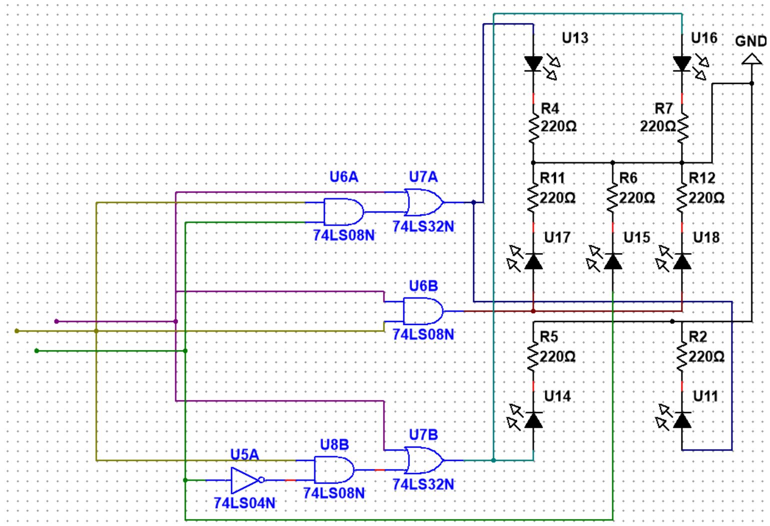
Analog Circuit



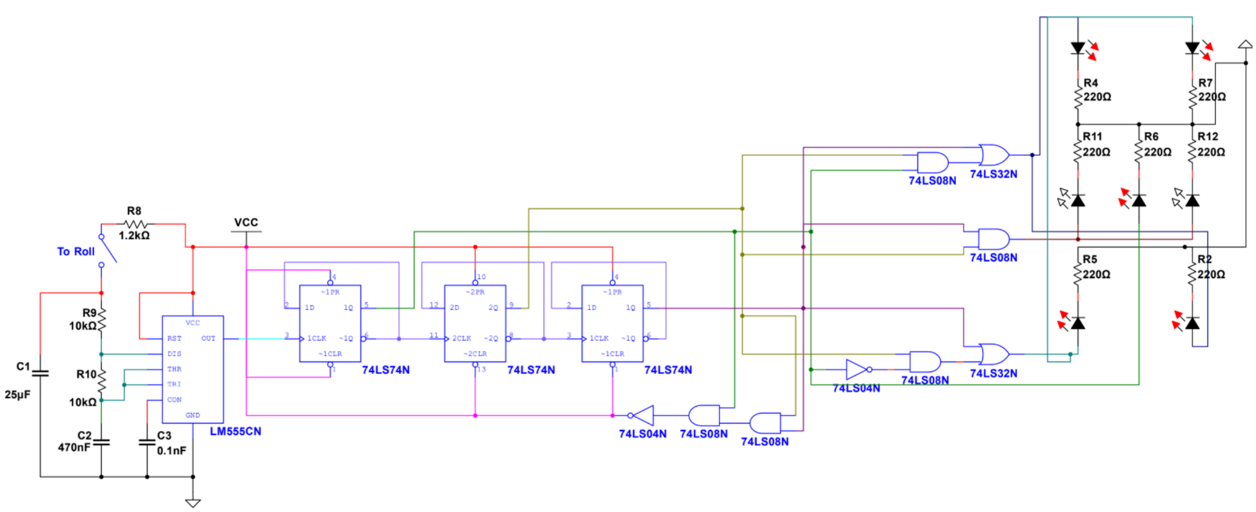
Sequential Logic Circuit



Combinational Logic Circuit



Full Circuit Schematic



Simulation Video Link

https://drive.google.com/file/d/1xpCVJa8JfvyNssVU7jyiEM5DNWaU5WeP/view

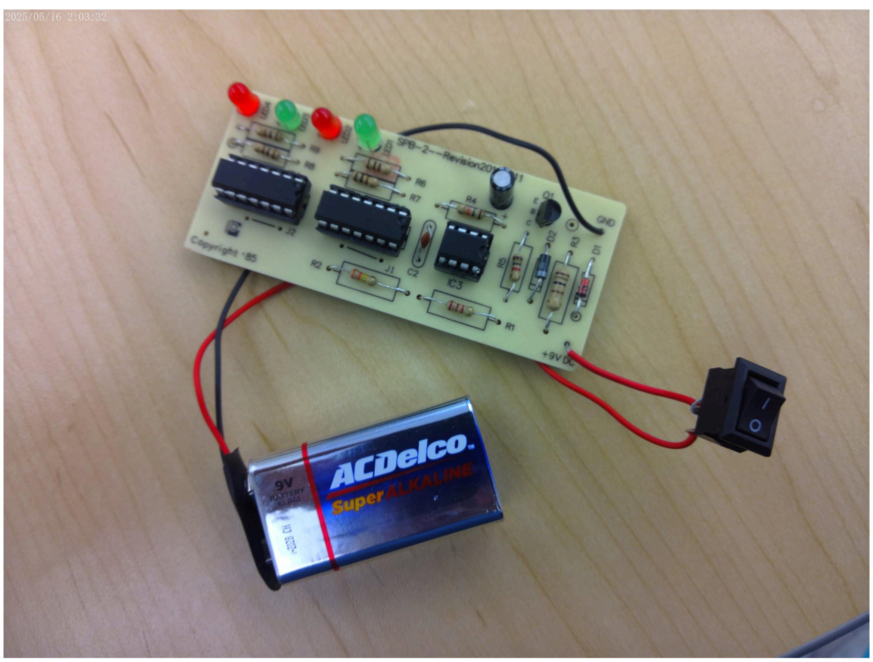
Reflection

Throughout this process, I learned a lot about the different components used in the circuit. For example, I learned how capacitors and capacitance worked, how 555 timers used resistors to vary their oscillation period, and how frequency dividers could serve as binary counters. I also gained knowledge on circuit design software (CDS) and utilized this knowledge to design the schematic in NI Multisim and make it easily followable at first glance.

One of the most memorable parts of this project was figuring out how the counter worked with my friend, Ibrahim. At the beginning of the project, we did not know how DFFs worked—however, by painstakingly tracing the wires, we determined how the counter functioned and improved our understanding of the circuit as a whole.

Physical Circuit

Photo



Video

https://drive.google.com/file/d/1JtksnguNchmeaS9pzhZxKaL6WhDvqanC/view