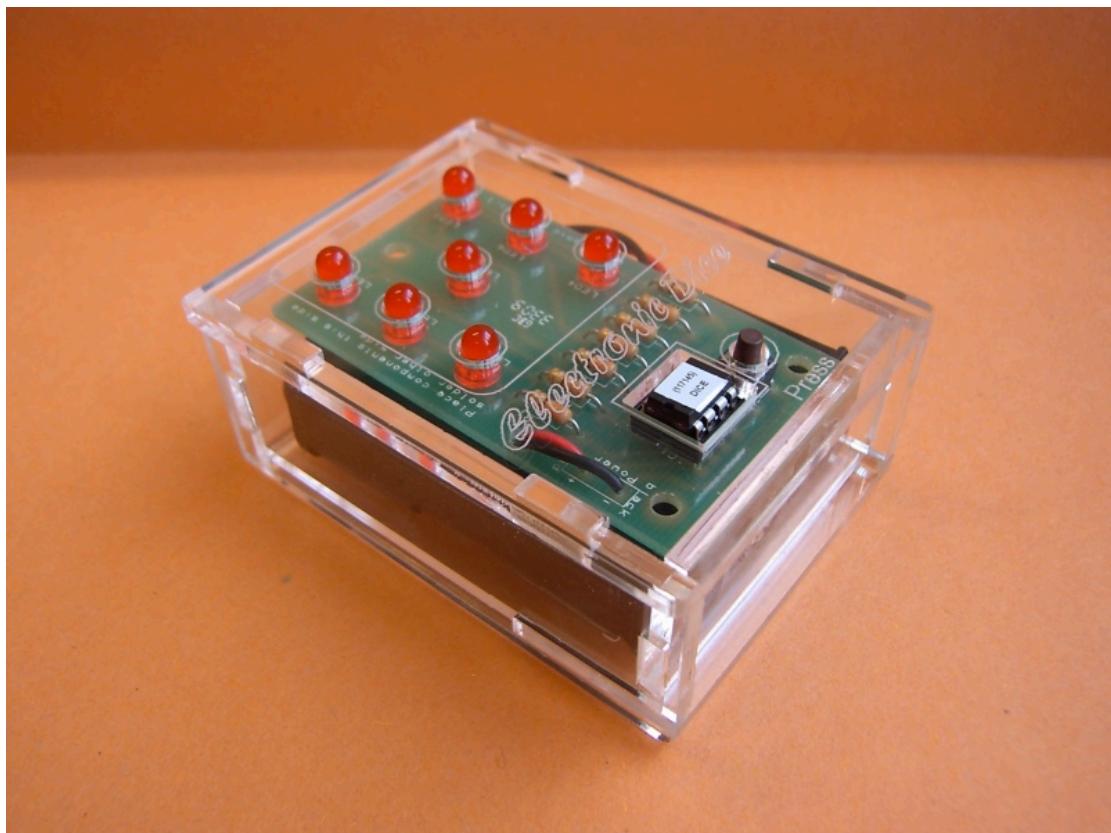


3C6b - Digital Electronics Design Project

Electronic dice project



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Abstract

- Summary of project/report

The project proposed was a circuit that replicated the roll of a dice as a method to get a random number at a push of a button. The circuit was designed and simulated using Multisim software and found to behave like expected. Next it was implemented in silicon and its logic module tested with the help of an Arduino microcontroller; the design passed all the tests to which was submitted and at the very end was connected to a signal generator and proved to be able to display random numbers between 1-6 at the push of the button as required.

This report describes in detail the process of design, testing and implementation of the above-mentioned circuit.

Introduction

- Overview of project and specification, and describes motivation for adoption of chosen design approach

This lab exercise was designed with the purpose to develop the practical knowledge of digital logic gates, displays, and the use of microprocessors such as Arduino. It was also meant to help students gain further experience in the design, simulation, implementation and testing of digital circuits. Also it was supposed to help develop the team-working capacities of the students and by the means of the requirement of the submission of a lab report it offered students an opportunity to practice their technical writing communication skills.

The exercise was chosen in such a way as to ensure the use of basic building blocks of digital circuits. It specifically required the use of the CD 4029 CMOS Presettable Up/Down Counter Chip. It also required the use of a prebuild LED circuit, which was to represent the numbers and a button used when a new roll of the dice was needed. The team of students were to come up with the logic needed for the LED display as well as with the overall design.

The design was chosen in order to simplify the overall circuit, minimize the number of components needed and maximise the use of the functionalities of the counter chip.

Circuit Description

Before describing the whole circuit some word have to be said about the functionality of the CD4029 chip itself. It is a presetable up/down counter chip, which counts by adding one value to the counter at every rising edge of the clock signal. It is worth mentioning some its useful functionalities as follows:

- Preset/enable – active high uses the 4 Jam inputs to reset to counter to the specified value
- Up/Down – makes the chip count upwards when high and downwards otherwise.
- Carry-out - active low is set when the counter reaches the maximum value while counting upwards or zero when counting downwards.
- Binary/Decade makes the chip count in binary when high and decade otherwise

Below, on figure 1, is a schematic representation of the CD4029 chip and its pin configuration.

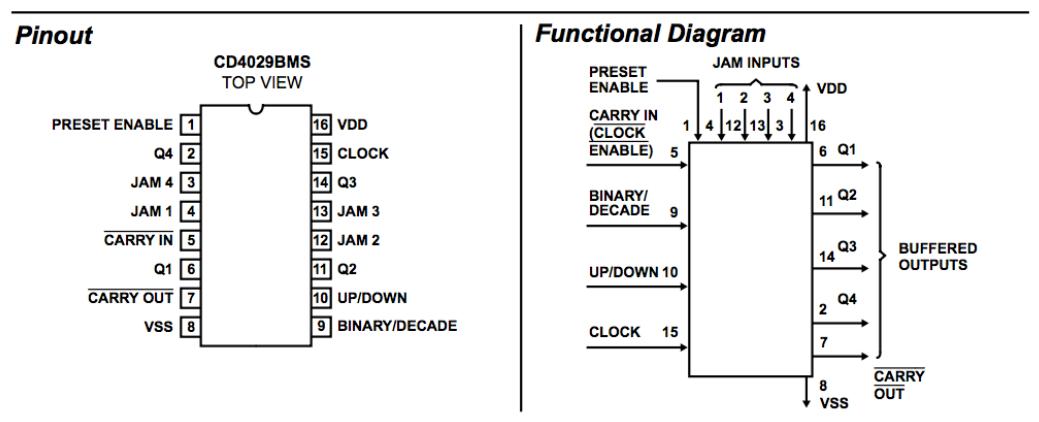


Figure 1 CD4029 Schematics

About the LED circuit can be said that it already integrated the resistors needed and it was set up in the way represented in figure 2 below. It only required the inputs and ground connection.



Figure 2 LED circuit schematics

The logic module required in order to accurately display the numbers outputted by the counter on the dice format was based on the logic table presented on figure 3 below. By choosing a range from 6-1 only 3 outputs were ever used which simplified the expressions as follows:

- C segment would be connected straight to the Q0 output of the counter
- D segments would be connected through an AND gate to the outputs Q1 and Q2
- B segments would connect straight to the Q2 output
- A segments would connect through an OR gate to the outputs Q2 and Q1

12	1 1 0 0	1 0 1 0	
13	1 1 0 1	1 1 0 0	
14	1 1 1 0	1 1 1 0	
15	1 1 1 1	1 1 0 1	
01	Q ₃ Q ₂ Q ₁ Q ₀	A B C D	
1	0 0 0 1	0 0 1 0	C = Q ₀
2	0 0 1 0	1 0 0 0	A = Q ₁ · Q ₂
3	0 0 1 1	1 0 1 0	B = Q ₂
4	0 1 0 0	1 1 0 0	A = Q ₂ + Q ₁
5	0 1 0 1	1 1 1 0	
6	0 1 1 0	1 1 0 1	
			CHAP NAMIE
			NOT C 0 89
			AND

Figure 3 Logic table and expressions for the inputs of the LED Circuit

The following approach was taken in order to design the overall circuit:

- The pin Binary/Decade was set high so the counter would operate in binary mode.
- The counter was set to count downwards by setting low the pin Up/Down
- The interval between 6-1 was chosen as operating range since it would simplify the logic for the LED driving circuit by using only 3 out of the four outputs since only 3 bits needed to represent in binary numbers on that interval.
- The Jam input pines were set as to represent 0101 that is binary for 6 base 10.
- The Carry Out signal was inverted and feed into the Preset/Enable pin and so used to reset the counter back to the value represented by the Jam inputs (6) and start again.
- The button was arranged as to disconnect the clock signal from the counter chip when idle and to close the connection when pressed.
- The 3 outputs were connected through the logic module to the LED circuit.

- An external dc power source (5v) was used to power the chips and the LED circuits while for the clock signal a signal generator was used to generate a square wave at the desired frequency as to serve of clock signal to the counting chip.

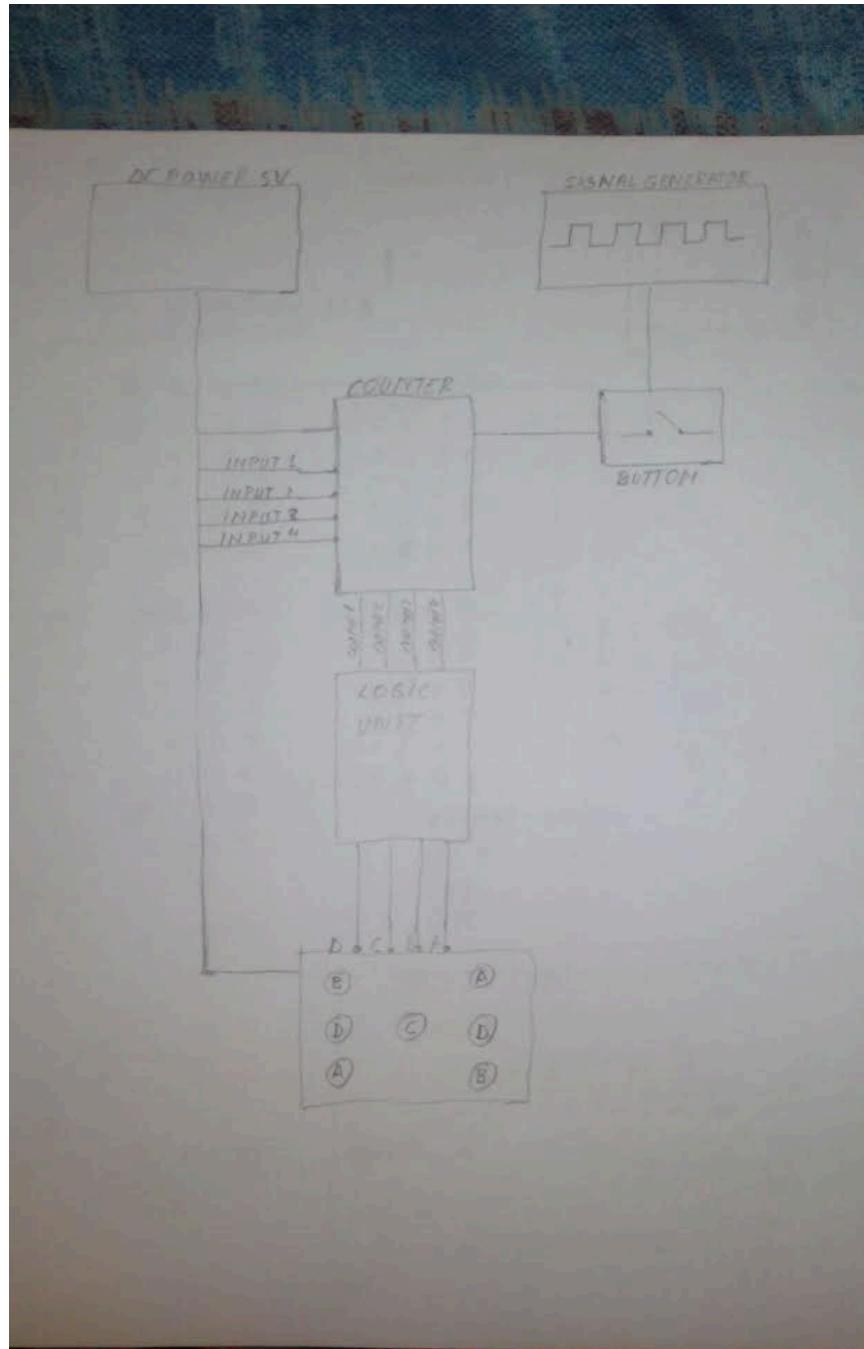


Figure 4 showing a block diagram representation of the circuit

Once the logic and block diagram were ready the simulation environment Multisim was used to implement a virtual version of the overall circuit. The

figure 5 below is a screenshot of the virtual version of the circuit on the Multisim environment.

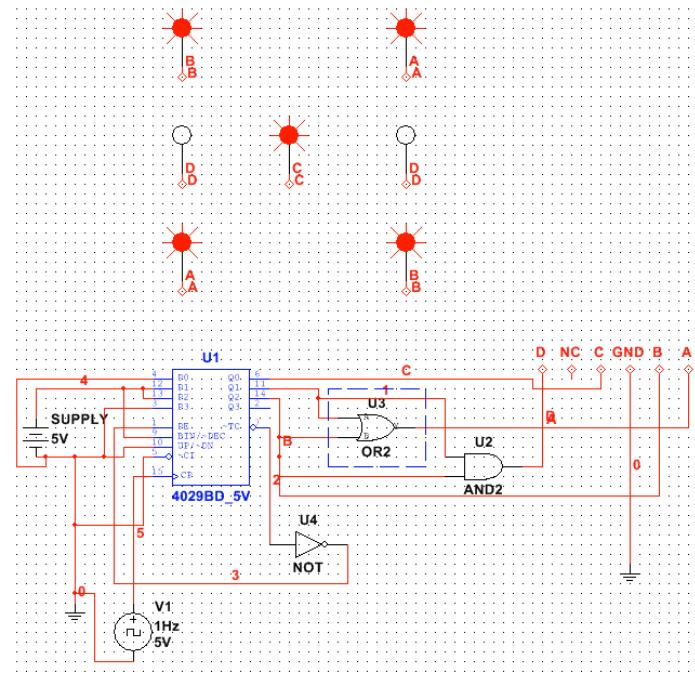


Figure 5 Screenshot of the virtual version of the circuit

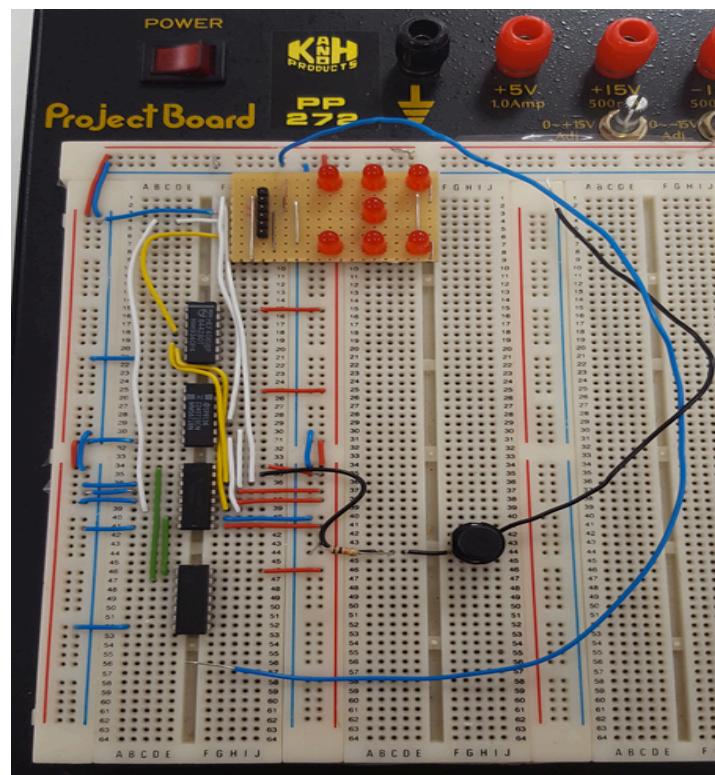


Figure 6 Final implementation of the circuit

Once the solution was shown to behave as expected the team split in two and half started to work on the physical implementation while the other half started designing the Arduino test code.

The chips were placed on a breadboard and the wiring was done according to the Multisim schematic. The wires were colour coded as follows:

- Red - 5V
- Blue - ground
- Black - clock signal
- Green - connection to the inverter chip
- White - connection between the counter outputs and the LED through the AND gate
- Yellow - connection between the counter and the LED through the OR gate

The chips were placed in such a way as to minimize the use of the breadboard and also such that the wiring would not get messy. This was considered to be good practice, as it would facilitate visual inspection needed for further testing and troubleshooting.

The button was connected to the clock pin of the counter through a resistor connected to ground in order to bring it down while not pressed and avoid a floating input.

Results

The tests performed on the Multisim environment showed the circuit was counting down and resetting as designed.

Once the physical implementation was completed end-to-end tests were performed with the voltmeter to ensure that the right connections were made and no faulty contacts occurred.

Next the Arduino microcontroller was used to test the logic module by providing it with test signals and ensuring the right LED combinations were obtained.

Last the signal generator was connected and it was discovered that the pin configuration of the LED panel was wrong due to human error. After the correction has been made the circuit behaved flawlessly passing all tests to which it was subjected.

Discussion/Conclusions

The design proved to be effective and stable. The team made a steady progress during the whole period without major time related pressure.

Given more time a set of test values could be implemented for each module of the circuit using the Arduino microcontroller. Also more careful consideration should be given supplementary checks in order to avoid human errors like the one that occurred due to time pressure.

The exercise as a whole proved to be a very engaging and it achieved its main objectives as a learning tool.