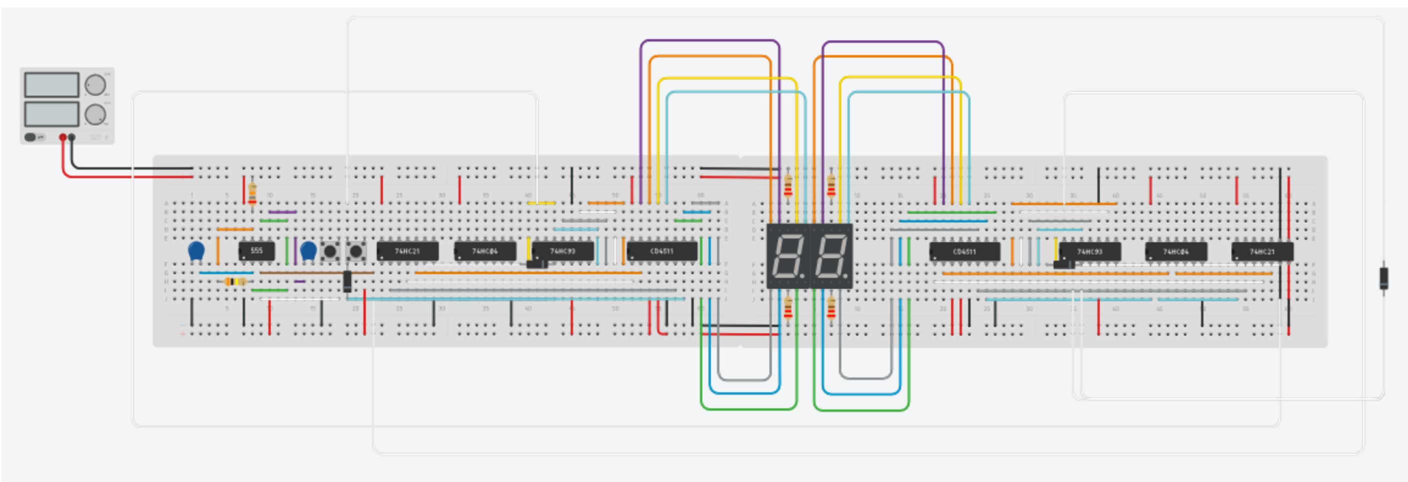
Digital Electronic Project



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Summary

Purpose

The purpose of this circuit is to demonstrate a two digit cathode display capable of counting from 00_{10} to 99_{10} where the decimal digits are incremented by one every two seconds. Although the counts are automatically controlled by different clock signals, the counts are also controlled manually by 2 pushbuttons. The left-most pushbutton holds the count steady whereas the right-most push buttons resets the count to 00_{10}. Likewise, the count is automatically reset to 00_{10} once the count reaches 99_{10} hence it starts counting up again, repeating the whole process.

Functionality

The circuit uses various IC chips to function the way it's supposed to. The IC chips used in this circuit include the 555 timer, ripple counter, 7-segment decoder, and a 7-segment display. To begin with, the 555 timer acts as a clock signal to the first ripple counter (units decimal) and since this circuit is asynchronous the second ripple counter (tens decimal) gets the clock pulse from the AND gate of the first ripple counter (units decimal). Additionally, the 4 bit binary counter ranges from 0-15 however in this circuit I wired it such that the 4 bit binary counter counts only from 0-9. This was achieved by using the AND gate as well as the NOT gate such that when the gates read 0101 the 4 bit binary counter is automatically reset to 0. This being said, when the first decoder (units decimal) reaches 9, it resets and increments the count of the second ripple counter (tens decimal) by 1. Hence the only time both displays reset to 00_{10} is after both displays have shown 99_{10}. Lastly, the 7 segment decoder simply takes the four binary inputs from the 4 bit binary counter and displays those binary inputs onto the 7 segment display in the decimal form. Overall, I am extremely content with the functionality of my circuit and I developed a lot of new knowledge and skills in the process of making this summative.

Part List

Component	Quantity
Power Connector (5V)	1
Pushbutton	2
Dual 4-Input AND Gate (74HC21)	2
Hex Inverter (74HC04)	2
4-Bit Binary Counter (74HC93)	2
7-Segment Decoder (CD4511)	2
7-Segment Display	2
555 Timer	1
Capacitor	2
Resistors	6
Diodes	4

Wire List

In order to make the circuit organized and easy to troubleshoot, I have colour coded all wires based on their segments for both common cathode displays. I have also used the standard colour codes for the power and ground wires. Refer to the table below where I have listed all the colour codes for different wires.

Yellow	Segment a
Turquoise	Segment b
Green	Segment c
Brown	Segment d
Grey	Segment e
Purple	Segment f
Orange	Segment g
Red	Power (VCC)
Black	Ground (GND)

Circuit Operation

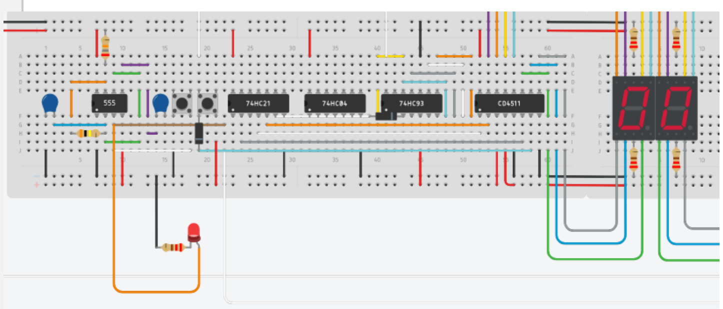
555 Timer

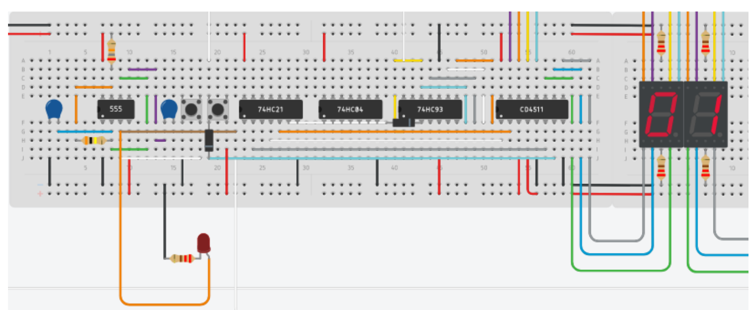
Description

The 555 timer is a precision timing mechanism that can be used as a single-pulse timer or a long-time delay timer. The duty cycle varies depending on the external capacitance and resistance.

Purpose

In my circuit, the purpose of the 555 timer is to act as the clock signal to the ripple counter hence it makes a negative transition every 2 seconds. This timing is achieved by setting the resistors and capacitors to a specific value which I had calculated using the frequency and duty cycle formulas. Refer page 8 to see the calculations. Moreover, when the clock input from the 555 timer is going from 0 to 1 (PGT) the counter is not being triggered, however when the 555 timer goes from 1-0 (NGT), the ripple counter is triggered hence it counts up on the display. This means that the 555 timer is NGT (negative going transition) as the ripple counter only counts up when it makes a negative transition (1 to 0).





As you can see in my circuit I tested the transition of the 555 timer using an LED. I found that when the ripple counter is not counting, the LED remains HIGH, however when the ripple counter gets triggered by the 555 timer and counts up to 1, the led goes from HIGH to LOW (1-0). This proved to me that my 555 timer is NGT.

4 Bit Binary Counter

Description

The 4 bit binary counter is an asynchronous device that is able to count from 0_{10} to 15_{10}. This device is usually controlled by clock pulses where the external clock is used to clock only the first flip-flop. Thus, the output of the previous flip-flop is used to clock all subsequent flip-flops. Hence, this device is asynchronous as the flip flops are supplied by different clock signals.

Purpose

In my circuit, the purpose of the 4 bit binary counter is to count from 0_{10}-9_{10} ignoring the numbers from 10_{10}-15_{10}. Since my circuit counts from 00_{10}-99_{10}, my circuit consists of two ripple-counters which asynchronously work together such that the first ripple counter (units decimal) receives a clock signal from the 555 timer, where the second ripple counter (Tens decimal) receives a clock signal from the output of the first ripple-counters which only outputs a high signal when the first ripple counter counts till 9_{10}. This process goes from 00_{10}-99_{10} hence once the 99_{10} is shown on the display, the ripple counter resets the display to 00_{10}.

7 Segment Decoder

Description

The 7 segment decoder is a combination of logic circuits that accepts binary inputs (A,B,C,D) and generates an appropriate output for the 7 segment display. For instance, if the binary inputs are 0010, the 7 segment decoder will output 4 on the display by turning ON the led b,c,f and g in the 7 segment display. This is because 0010 in binary is equivalent to 4 in decimal.

Purpose

In my circuit the purpose of the 7 segment decoder is to simply convert binary inputs into its decimal form onto the 7 segment display. Hence we send in 4 bits from the 4 Bit Binary counter to the seven segment decoder and they get converted into the appropriate 7 outputs for the seven segment display.

7 Segment Display

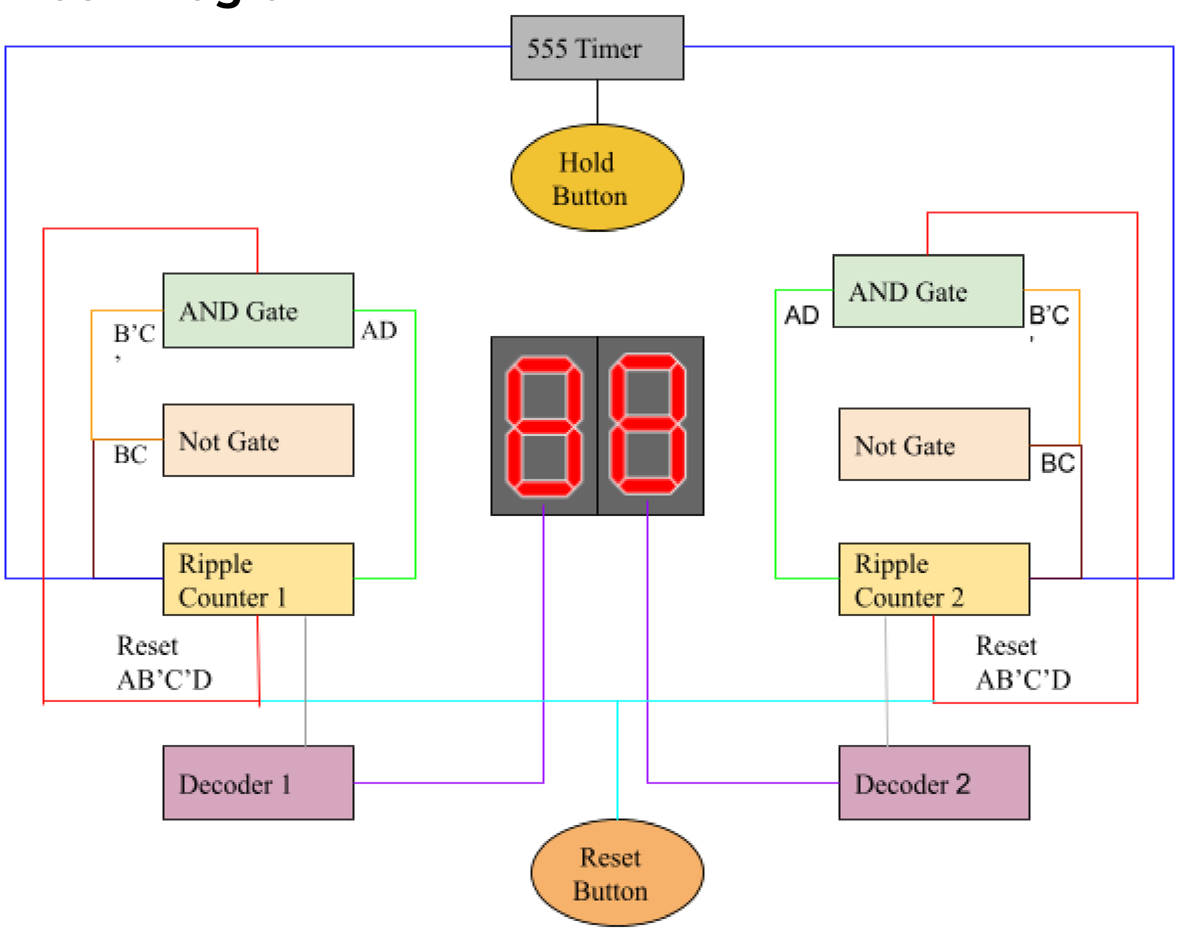
Description

A seven-segment display is a form of electronic display system for showing decimal numbers. It consists of 7 different LEDs ranging from A-F. These LEDs all work together and light up in order to show certain decimal numbers.

Purpose

The 7-segment display receives inputs for individual segments from the 7-segment decoder and lights up the appropriate segments based on the input. Each segment has its corresponding inputs, hence whatever binary digit the decoder decodes it sends it over to the 7-segment display to be displayed as a base 10 digit. Additionally, the 7-segments displays are all set to cathode hence pin 3 and 8 are both connected to ground (GND) with a 220 ohms resistor. Due to this, any high inputs from the decoder will light up the display.

Block Diagram



Calculations

Information

$C = 8.2\ \mu F$ $DC = 92\%$ $T = 2s$ $R_A = ?$ $R_B = ?$

Frequency

$$T = 0.693\,(R_A + 2R_B)\,C$$

$$2 = 0.693\,(R_A + 2R_B)\,0.0000082$$

$$2 = 5.6826 \times 10^{-6}\,(R_A + 2R_B)$$

$$351951.5715 = R_A + 2R_B$$

$$R_A = 351951.5715 - 2R_B$$

Duty Cycle

$$DC = \frac{(R_A + R_B)}{(R_A + 2R_B)} \times 100\%$$

$$0.92 = \frac{(R_A + R_B)}{(R_A + 2R_B)}$$

$$0.92R_A + 1.84R_B = R_A + R_B$$

$$1.84R_B - R_B = R_A - 0.92R_A$$

$$\frac{0.84R_B}{0.08} = \frac{0.08R_A}{0.08}$$

$$10.5R_B = R_A$$

Subtitute to solve for R_B

$$351951.5715 - 2R_B = 10.5R_B$$

$$351951.5715 = 12.5R_B$$

$$28156.12572\,\Omega = R_B$$

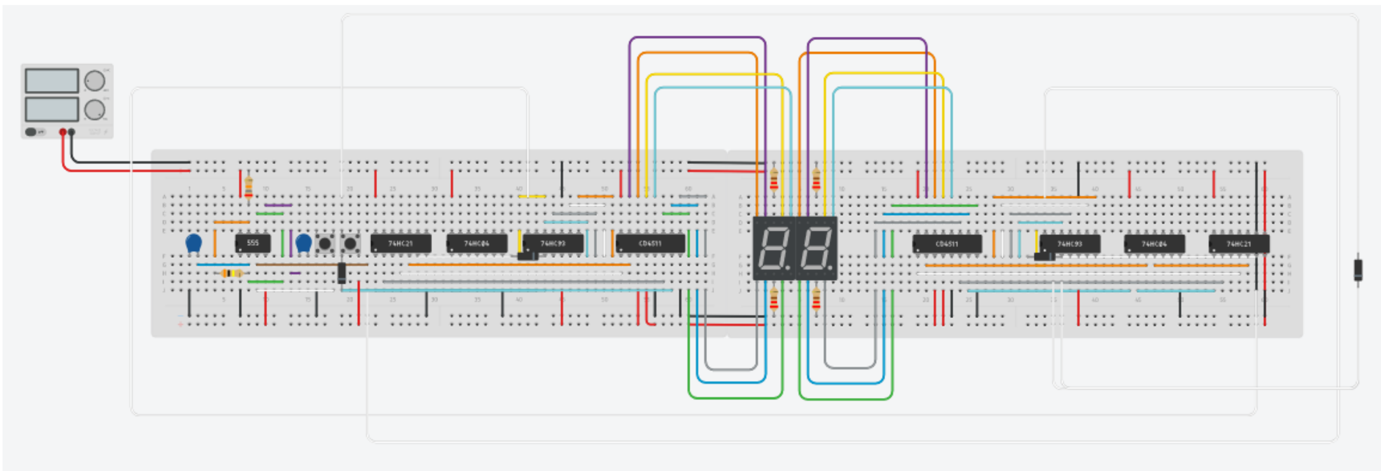
Subtitute to Solve for R_A

$$R_A = 10.5\,(28156.12572)$$

$$R_A = 295639.3201\,\Omega$$

Tinkercad Circuit

Circuit Screenshot



Tinkercad Link

https://www.tinkercad.com/things/06Lrtjdy94c-digital-electronics-project-gurpreet-singh/editel

Discussion

1. **What is the difference between a common cathode and common anode type of 7-segment display?**
   A common cathode 7-Segment Display is one that is at a low state “0”. Hence a common cathode display is an active HIGH as it requires high inputs in order to light up its segments. For instance, a high input must be sent to all the segment pins in order to display 8 in decimal. Adding on, the common pins of a Common Cathode 7 Segment Display must be connected to ground (GND) in order for it to function.
   On the flip side, a common anode 7-Segment Display is one that is at high state “1”. Hence a common anode display is an active LOW as it requires a low input in order to light up its segments. For example, a low input must be sent to all the segment pins in order to display 8 in decimal. Furthermore, the common pins of a Common Anode 7-Segment Display must be connected to VCC in order for it to function.

2. **Find ONE specific example of a synchronous counter IC chip. What is its name and part number ? How does it work? Be detailed in explaining how it uses flip flop circuits to count. You should mention at least one specific type of flip flop.**
   A synchronized counter is one in which all of the flip flops are clocked at the same time using the same clock input. This eliminates any large delays with the ripple counter that often occurs in the asynchronous counters. The BCD Decade Up/Down Counter is a great example of a basic synchronous counter IC chip. This chip is identified by part number 74HC190. It is specifically used to count from 0 to 10, with the numbers shown in a range of formats such as 0001, 1000, 0010, and so on. In order to count, this chip uses four JK flip flops, each of which is attached to a single clock, the external clock. Furthermore, JK flip flops function similarly to SR flip flops, however, JK flip flops have a clock, hence there is no Prohibited State. Besides, the NAND gates play a major role

in resetting the counter such that when the inputs B and D are ON, the binary number 10 is reached, thus, the NAND gate is enabled, resetting the count to 0000. Adding on to this, the 74HC190 chip also has a reset button that effectively resets the entire count to 0000 through the use of NAND gates. Moreover, the flip flop counts very similarly to the 4 bit binary counter that I used in my circuit as they both require an external clock input, which in my case was the 555 timer to send the clock pulse after every 2 seconds which was my desired delay time. Overall, the 74HC190 is a great example of a synchronous counter and you can learn a lot about flip flops from this specific IC chip.

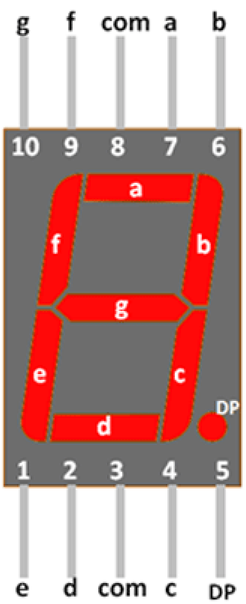
3. **You have used a ripple counter chip in this circuit. How is it different from a synchronous counter?**
   There are various differences between a ripple counter chip used in my circuit and a synchronous counter. To start with, the ripple counter used in my circuit has two separate clock inputs, while the synchronous counters have only one clock input. This is because the ripple counter functions such that the output of one counter stage is connected directly to the clock input of the next counter stage and so on along the chain. whereas the synchronous counters all receive the same clock input hence they are clocked together simultaneously, resulting in a fixed time relationship. In my circuit, the first 4 ripple counter receives a clock pulse from the 555 timers and the second ripple counter receives the output of the first ripple counter. In addition, another major difference between the two counters is that the ripple counter ONLY is able to count in one specific sequence (up or down) however, synchronous counters are able to count in varieties of sequence depending on the wiring. Lastly, another difference is that the ripple counter tends to be slower than the synchronous counter. This is because the ripple counter all receive different clock inputs hence the timing is often inaccurate and unpredictable however the synchronous counters all receive the same clock input hence they tend to be much faster as all flip flops are triggered with the same clock at the same rate

4. **Why does the 4-Bit Binary Counter (74HC93) chip used in this summative have two clock inputs? What is the purpose of each clock?**
   The 4-Bit Binary Counter chip used in this summative has two clock inputs simply because it is an asynchronous counter. To start with, the first 4-Bit Binary counter (counting for the unit's decimal) receives a clock signal from the 555 timers every 2 seconds. Once the first 4-Bit Binary Counter receives a clock pulse, the four binary bits from the counter go through a combination of AND and NOT gate in which they essentially check whether the count of the first counter has reached 9_{10}. Once the count of the first 4-Bit Binary counter reaches 9 the AND gate provides a clock signal to the second 4-Bit Binary Counter, incrementing its value by 1. Overall, this is how the two 4-bit binary counters work together in order to display the count from 00_{10}-99_{10}.

5. **List any issues you had and how you resolved them. This can include wiring problems or issues learning about the new components. Also, mention how you resolved them.**
   One of the main issues that I experienced in the process of wiring this circuit was the wiring of the reset button. Initially, I was simply connecting the wires from my pushbutton to the reset pins with two resistors on both 4-Bit Binary Counters, however, this continuously kept burning my AND gates that were also connected to the reset pins. Hence every time I tried to reset the counter, the current kept flowing from the pushbutton straight to the AND gate causing it to have excess voltage and eventually burn. Due to this, the functionality of my push button was being disrupted allowing it to not work properly. However, after doing countless research, I finally resolved this issue by adding diodes to the reset pins. The diodes restricted the current to only flow one way hence it restricted the current from flowing the AND gates and burning it. Thus, this allowed my push button to function properly and reset the counter at any given moment in the simulation.. Overall, I am extremely proud of myself for facing all these barriers and being able to learn and take away something from my mistakes.

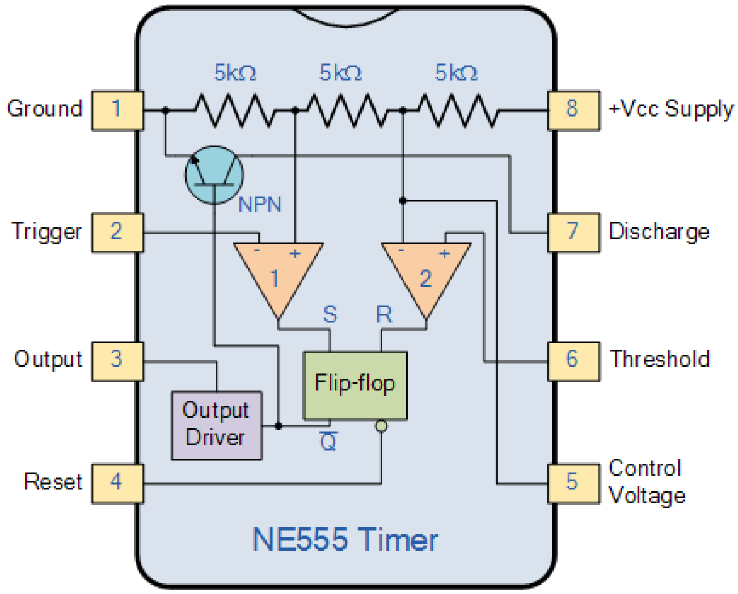
Appendix

7 Segment Display



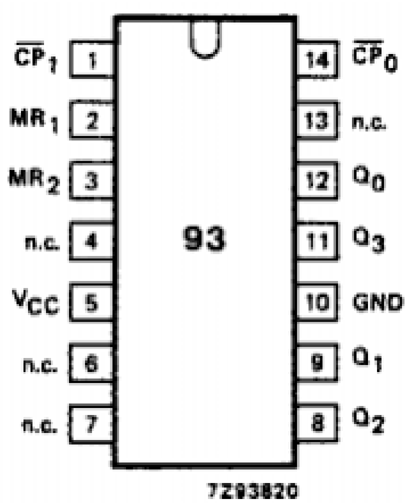
IC Datasheet
7 Segment Display: Pin Diagram, Description, Working, Types & Datasheet. Components101. (n.d.). https://components101.com/displays/7-segment-display-pinout-working-datasheet

555 Timer



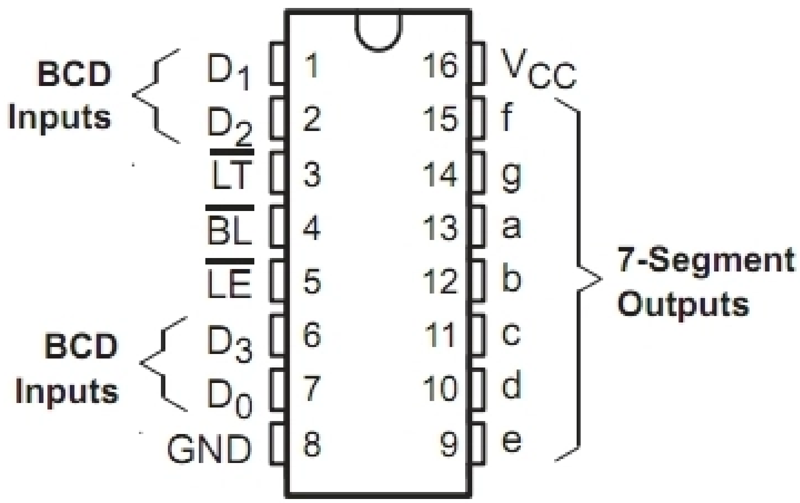
IC Datasheet
555 Timer Tutorial - The Monostable Multivibrator. Basic Electronics Tutorials. (2020, April 23). https://www.electronics-tutorials.ws/waveforms/555_timer.html.

4 Bit Binary Decoder (74HC93)



IC Datasheet
74HC93 counter. Datasheet pdf. Equivalent. 74HC93 counter Datasheet pdf - ripple counter. Equivalent, Catalog. (n.d.).
https://datasheetspdf.com/pdf/491809/Philips/74HC93/1.

7-Segment Decoder (CD4511)



IC Datasheet
CD4511 7-Segment Driver IC Pinout, Technical Details, Equivalents & Datasheet. Components101. (n.d.). https://components101.com/ics/cd4511-7-segment-driver-ic

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