DAVID SUZUKI SECONDARY SCHOOL

COMPUTER ENGINEERING

TEJ4M0-B

DIGITAL ELECTRONICS SUMMATIVE

Prepared for: Mr. Rai

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SUMMARY

Purpose

The objective of this summative project is to build a counter that is capable of counting from decimal values 0 to 9, at least. An advancement was added in order for the circuit to count from 0 to 99. In order to build this circuit, four main sub-circuit components were required: a clock pulse circuit (555 Timer), two decade counter circuits (74LS192), two binary to decimal decoder circuits (74LS47), and two common-anode type seven segment displays to display the count to the user. The circuit must count upwards, incrementing every second and must restart its count at 0 once the count reaches 99, on the seven segment display. All in all, the purpose of the circuit is to count to 99 and display the count on a seven-segment display, while incrementing at a particular interval.

Functionality

In terms of functionality, the circuit begins with the 555 timer which generates a clock pulse of 1 second and must have a duty cycle of 75%. This means the the number displayed must be displayed 0.75 seconds of the 1 second of clock pulse duration, and off for 0.25 seconds. Using the given 555 timer equations, the accurate resistor values for R_1 and R_2 for the 555 timer circuit were calculated in order to generate a 1 second clock pulse as well as 75% duty cycle. Secondly, the output of the 555 timer is connected, using circuit wiring, to the clock-UP input of the decade counter. With this decade counter implemented, the circuit is capable of incrementing every second as needed. The decade counter consists of 4 outputs (Q_A, Q_B, Q_C, Q_D), which represent binary numbers, are wired to their corresponding letters on the decoder IC, as seen in the circuit diagram below. Once wired correctly, the outputs of the decoder chip (a, b, c, d, e, f, g) are wired to corresponding letters on the seven-segment display. The outputs of the decoder chip are inverted, which does work well with the common-anode type as the segments must be grounded. To add a second seven segment display, the decade counter, decoder and common anode are wired the same but Pin 12 (Carry Out) of the first digit's decade counter is connected to Pin 5 (UP) of the second digit's decade counter. Essentially, depending on the input from the decade counter to the decoder IC, a low input is given to corresponding segments on the common-anode in order to display the appropriate number. This part of of circuit functions in this form because it is an active-low circuit, meaning the input is 'pulled' to ground.

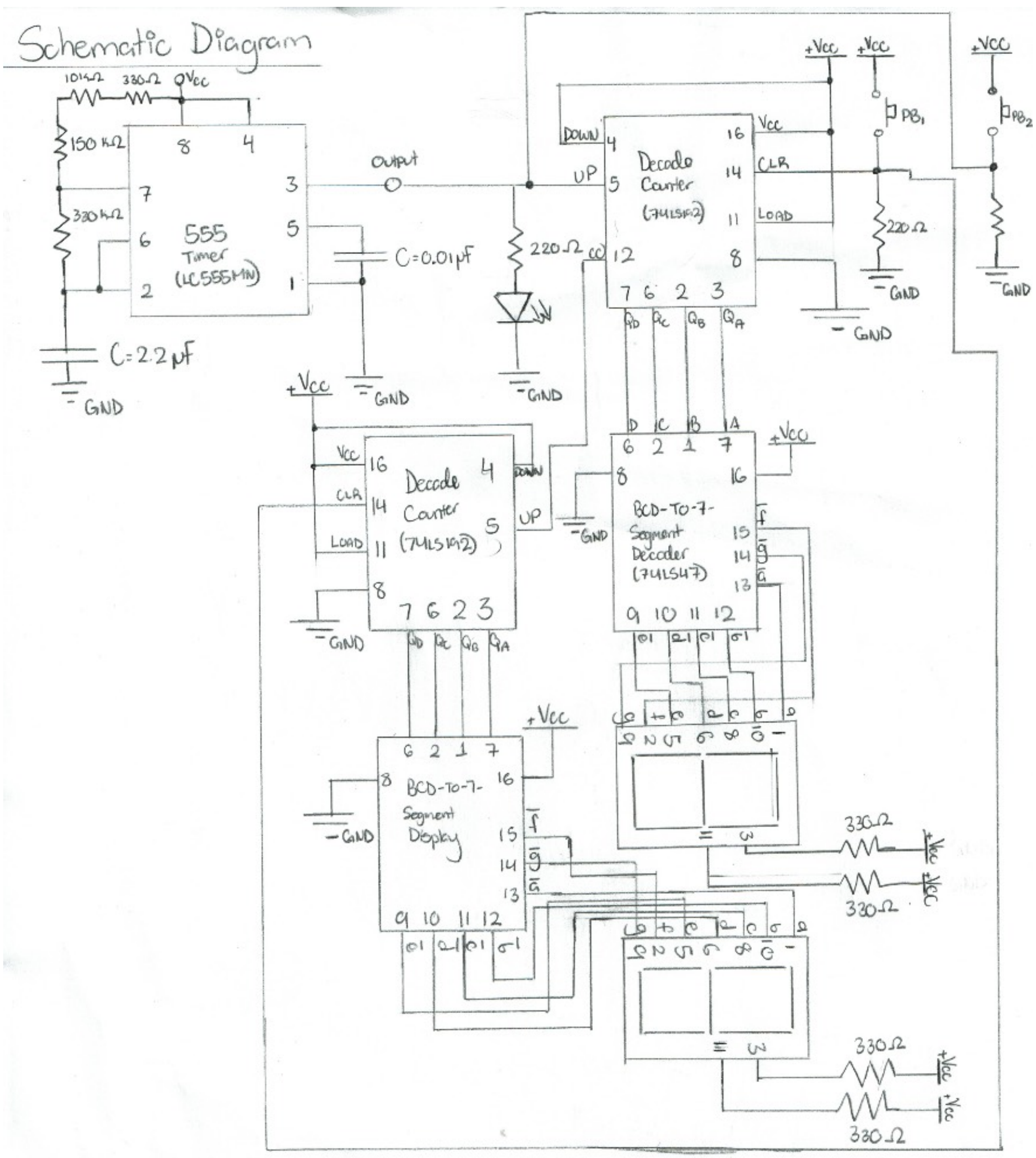
Additionally, the circuit contains one push-button to hold the count steady on the seven-segment display when desired and a second push-button to reset the count of both digits back to 0 when pressed.

PARTS LIST

- Clock Pulse Circuit 555 Timer (LM55CN) (1)
- Decade Counter Circuit (74LS192) (2)
- BCD-To-Seven-Segment Decoder Circuit (74LS47) (2)
- Seven-Segment Display (Common Anode Type) (2)
- Light-Emitting Diode (LED) (1)
- Resistors:
  - 330 kΩ (5)

- 150 kΩ (1)
- 10 kΩ (1)
- 220 Ω (1)
- Push-buttons (2)
- Capacitors:
    - 2.2 μF (1)
    - 0.01 μF (103M) (1)
- Wires: Red (to +5 V), Black (to 0 V), and Yellow (control wiring)
- Breadboard (1)

SCHEMATIC DIAGRAM



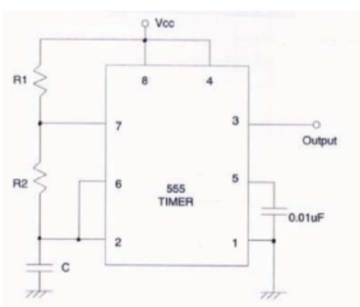
CIRCUIT OPERATION

555 Timer (LM555CN)

Description: The LM555 is a highly stable device for generating accurate time delays or oscillation. Additional terminals are provided for triggering or resetting if desired. In the time delay mode of operation, the time is precisely controlled by one external resistor and capacitor. For a stable operation as an oscillator, the free running frequency and duty cycle are accurately controlled with two external resistors and one capacitor. The IC contains a monostable mode and astable mode. In the monostable mode, the 555 timer functions as a 'one-shot' and can be used for a timer or a bounce-free switch. In the astable mode, the 555 timer functions as an oscillator and could be used for a lamp flasher, logic clock, or pulse generator. This circuit uses astable mode in order to generate a clock pulse.

Purpose: In this circuit, the purpose of the 555 timer is to generate a 1 second clock pulse that also has a 75% duty cycle. The 555 timer is crucial in order for the counter to count at an increment with a specific time interval. The 555 timer is designed in oscillator mode, which requires 2 external resistors as well as a capacitor. The values for R_1 and R_2 were calculated using the 555 Timer design equations in order to generate a 75% duty cycle.

Block Diagram



The 555 Timer consists of 8 inputs where Pin 3 , being the output of the clock pulse, is connected to Pin 5 of the decade counter circuit. The values of R_1 and R_2 are calculated using given equations to generate a specific clock pulse and duty cycle. Since the 555 Timer is in oscillator mode, the circuit must contain one capacitor at least.

Calculations for R_1 and R_2:

Calculations for R_1/R_2

① $T = 0.693(R_A + 2R_B)C$

$1 = 0.693(R_A + 2R_B)\, 2.2\,\mu F$

$\frac{1}{(.693)(2.2\times10^{-6}\,F)} = R_A + 2R_B$

$\frac{1}{1.52\times10\times10^{-6}} = R_A + 2R_B$

③ — Sub ② into ①

$\frac{1}{1.52\times10^{-6}} = (2R_B) + 2R_B$

$\frac{1}{1.52\times10^{-6}} \div \frac{4}{1} = 4R_B$

$163977\,\Omega = R_B$

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

$.75(R_A + 2R_B) = R_A + R_B$

$.75R_A + 1.5R_B - R_B = R_A$

$.75R_A + 0.5R_B = R_A$

$2R_B = R_A$

④ Sub R_B into ②

$2(163977) = R_A$

$327955\,\Omega = R_A$

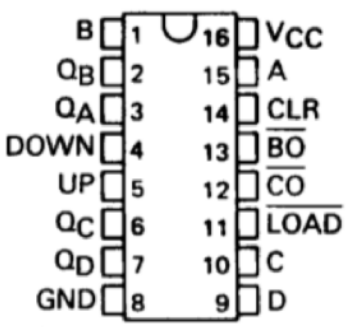
$\therefore$ **R_A = 327 955 Ω**
and R_B = 163 977 Ω

Decade Counter (74LS192)

Description: The decade counter, also known as synchronous up/down decade counter is a synchronous counter in which the internal J-K flip-flops trigger in sync with the clock pulse. The decade counter can count in BCD, or binary coded decimal, from 0-9 either going up or down depending on circuit wiring. In this case, the circuit is wired to count from 0 to 9 (upward) and once reaching 9 the count will restart from 0.

Purpose: The decade counter is essential in counting from 0-9 in this circuit, which is produced in BCD language in the form of the first 4 columns of the binary counting system (1s, 2s, 4s, 8s). To reset the count, as needed, the clear input has to be powered to reset the count. The count of the decade counter is held steady by powering the clock-up (UP) input of the decade counter or the output of 555 timer (Pin 5).

Block Diagram



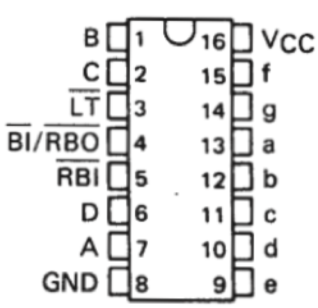
As seen in the block diagram, the BCD is represented by inputs Q_A, Q_B, Q_C, Q_D, which are equivalent to the 1s, 2s, 4s, and 8s of the count respectively. The decade counter is capable of counting at an increment because it is connected to the 555 Timer through Pin 5. To reset the count, the CLR pin, or Pin 14, must powered.

Binary to Decimal Decoder (74LS47)

Description: This IC features active-low outputs designed for driving common anode LEDs or incandescent indicators directly. This chip has full ripple-blanking input/output controls and a lamp test input. It also incorporates automatic leading and/or trailing-edge zero-blanking control and is designed to offer a choice between two indicator fonts. This chip can take in BCD an the input and output the pattern into a seven-segment displaying numbers 0-9. The outputs of the decoder contain a to g which are the designated inputs on the seven-segment display.

Purpose: The purpose of the decoder in this circuit is to drive the seven-segment and display the count in terms of 0-9. The inputs are in binary coded decimal, so the inputs of this chip are Q_A, Q_B, Q_C, Q_D, originating from the decade counter. The chip will then convert the inputs into specific output patterns in order to illuminate different portions of the seven-segment in order to produce a number from 0 to 9. Because the outputs are designed to be LOW in this case; the circuit works perfectly with common anode type seven-segment displays.

Block Diagram



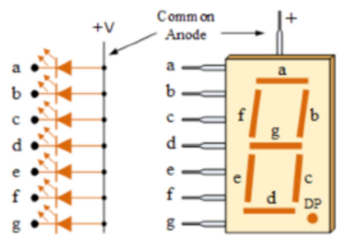
The diagram shows the inputs being A, B, C, and D from the decade counter portion and pins 9-15 are the outputs designated for the seven-segment display.

Display (Common Anode Seven-Segment Display)

Description: The anode connections of the LED segments are joined together to logic “1”, or HIGH. The individual segments are illuminated by applying a ground, logic “0” or “LOW” signal using a suitable current limiting resistor to the Cathode of the particular segment (a-g).

Purpose: Display the count of 0-9 to the user.

Block Diagram



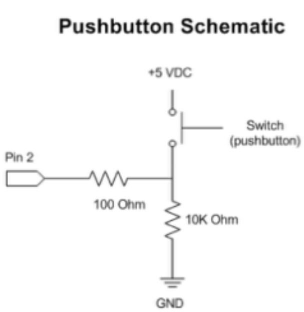
In the block diagram, it is clear that all of anodes of the seven-segments are connected together. So, by applying a ground to a particular segment connection (a-g), the appropriate segment will illuminate, which is dependent on the number needed to be displayed.

Pushbuttons

Description: Push buttons are a control device that is used operate an electrical circuit by either closing or opening the circuit. When pressed, the circuit is complete and vice-versa when not pressed.

Purpose: In this circuit, there are 2 pushbuttons; one pushbutton is used to hold the count steady on the seven-segment display. Another pushbutton is used to reset the count back to 0 when pressed. Both use a pull-down resistor to pull the input to ground (0 V).

Block Diagram



In the diagram, a pushbutton requires the pull-down resistor in order to pull the input to ground when not pressed.

DISCUSSION

1. The are two types of 7-segment display which is the common cathode and the common anode. In an common cathode, all the connections of LED’s are joined together to ground. Each individual segment is illuminated by a **HIGH** which is sent a signal send by a resistor which limits current. In an common cathode, positive current flows out so the seven-segment display must be grounded. Similarly, in the common anode, all the connections of LED’s are joined together to a certain voltage. Each individual segment is illuminated by applying

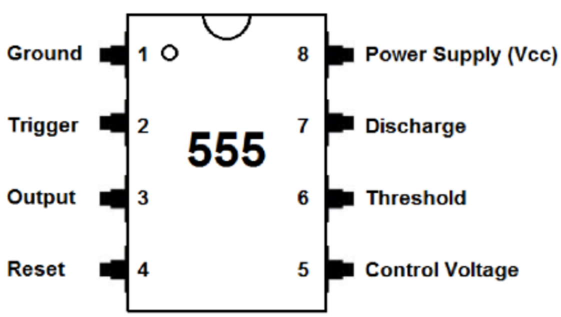
ground, **LOW** signal by a resistor. Common anode means that the positive side of the LED's connected to each pin because in an common anode the current flows-in from the outside. In an common cathode, positive current flows out so the seven segments must be grounded. When wiring the seven segment display we had to take into consideration that the input coming from the decoder chip did not need to be inverted and that the pins connect to power through a resistor rather than ground compared to the common cathode. In conclusion, by using a common anode seven segment display the wiring became neater since the output from the decoder chip was not inverted.

2. To count down instead of up output from the 555 timer needs to be connected to pin 4 for the decade counter rather than pin 5 which is for clock-up. As well, Pushbutton #2 must be connected to Pin 4 (DOWN) of the first digit decade counter rather than Pin 5 (UP).

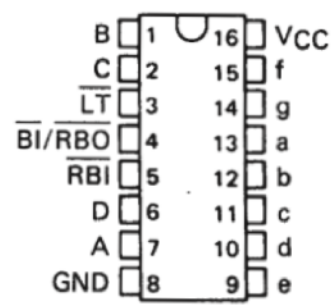
3. The count doesn't always resume from where the count was stopped using the switch. This happened because of switch bouncing which is means of a single press to appear as multiple presses. Switch bouncing occurs because when two metals contact inside the pushbutton they make multiple signals as the contacts open or close. This can be prevented using a de-bounce circuit which refers to a software of device that makes sure there is only a single signal for the opening or closing of a contact inside the pushbutton. To de-bounce the circuit a capacitor could be used to filter out any of the sudden changes that occur in the switch signal.

APPENDIX

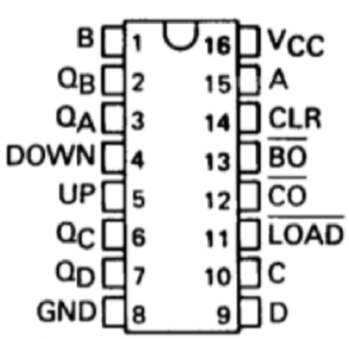
555 Timer (LM55CN)



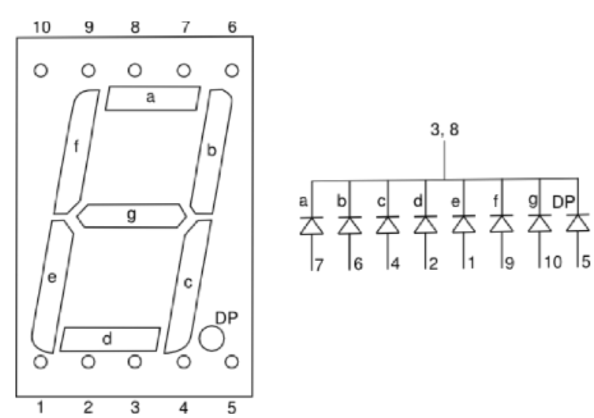
BCD-To-Seven-Segment Decoder Circuit (74LS47)



Decade Counter Circuit (74LS192)



Seven-Segment Display (Common Anode Type)



Datasheets and Resources Links

- http://www.ti.com/lit/ds/symlink/lm555.pdf
- http://pdf1.alldatasheet.com/datasheet-pdf/view/246777/RENESAS/HD74LS192P.html
- http://www.ti.com/lit/ds/symlink/sn5447a.pdf
- https://e-radionica.com/productdata/LD3361BS.pdf

- http://www.electronics-tutorials.ws/blog/7-segment-display-tutorial.html
- http://www.wisc-online.com/Objects/ViewObject.aspx?ID=DIG7307
- http://www.interfacebus.com/ic-4-bit-decade-counter-74192.html

EVALUATION RUBRIC

Names: Jonathan and Pavneet

Criteria	Level 1 (50 – 59%)	Level 2 (60 – 69%)	Level 3 (70 – 79%)	Level 4 (80 – 100%)
Understanding of electronics, digital integrated circuits. (Knowledge) __________/10	Demonstrates limited understanding of ☐ Electronic components (resistors, LEDs switches) ☐ Digital Integrated circuits.	Demonstrates some understanding of ☐ Electronic components (resistors, LEDs switches) ☐ Digital Integrated circuits.	Demonstrates considerable understanding of ☐ Electronic components (resistors, LEDs switches) ☐ Digital Integrated circuits.	Demonstrates outstanding understanding of ☐ Electronic components (resistors, LEDs switches) ☐ Digital Integrated circuits.
Circuit design and breadboard wiring. (Thinking / Inquiry) __________/10	Circuit design and breadboard wiring ☐ Circuit not functional. ☐ Wiring is not neat. ☐ Wiring does not follow colour standards ☐ Missing required functionality.	Circuit design and breadboard wiring ☐ Circuit is somewhat functional. ☐ Wiring is somewhat neat. ☐ Wiring does not always follow colour standards ☐ Most required functionality present.	Circuit design and breadboard wiring ☐ Circuit is functional. ☐ Wiring is neat. ☐ Wiring always follows colour standards ☐ All required functionality present.	Circuit design and breadboard wiring ☐ Circuit is functional. ☐ Wiring is exceptionally neat. ☐ Wiring always follows colour standards ☐ Circuit includes enhancements.
Project Report Documentation **Requirements met** (Communication) __________/10	Project Documentation: ☐ Few or no project report requirements met. ☐ Report not neatly typed/presented. ☐ Contains many spelling mistakes.	Project Documentation: ☐ Some project report requirements met. ☐ Report somewhat neatly typed/presented. ☐ Contains some spelling mistakes.	Project Documentation: ☐ Most project report requirements met. ☐ Report neatly typed/presented. ☐ Contains only a few spelling mistakes.	Project Documentation: ☐ All project report requirements met. ☐ Report typed and presented extremely well. ☐ Contains no spelling mistakes.