BCD COUNTER

Logic Circuits Design

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Aim

The aim of this project is to design and implement a Binary Coded Decimal (BCD) Up/down counter capable of counting from 0 to 9 in both directions. The counter output is displayed through a 7-segment display, while an indicator LED switch each time the counter changes its state. This project demonstrates digital logic design concepts including sequential circuits, counter, display decoding, and visual feedback.

Introduction

Digital counter are essential components in almost every electronics system, from clocks and calculators to industrial measurement tools. A BCD counter is a special type of counter that represents decimal numbers (0-9) using binary coded decimal format. Unlike binary counters, a BCD counter resets automatically after reaching 9, making it ideal for human-readable displays.

In this project, we build a BCD Up/Down counter that can increase or decrease its count based on the user's control input. The current count is shown on a 7-segment display, which provides a clear and intuitive visual output. Additionally, an LED indicator is included to light up every time the counter flips, offering an immediate signal that the digital circuit has successfully transitioned between states.

This project combines sequential logic (flip-flip), combinational logic (7-segment decoder), and user interaction (up/down control). It serves as a practical demonstration of how digital circuits can be used to build real-world devices that perform controlled counting and display tasks.

Analysis

The BCD up/down counter operates as sequential circuit. Internally, the counter uses a chain of flip-flops or a specialized IC (such as 74LS192) to generate the BCD output. The counter follows these keys behaviors:

1-Counting Logic

. Up mode: counts from (0-9), then resets to 0.

. Down mode: Counts from (9-0), then resets to 9.

2- BCD Encoding

The counter outputs a 4-bit BCD number:

. 0000=0

. 0001=1

. 0010=2

. 0011=3

. 0100=4

. 0101=5

. 0110=6

. 0111=7

. 1000=8

. 1001=9

Values above 9 are not allowed; therefore, the counter automatically turns to the valid range.

3- 7-Segnent Display Interface

Since the display cannot understand binary directly, a BCD-to-7-segment decoder (such as 7447 for common Anode) is connected.

Its role:

. Reads BCD input.

. lights the correct segment (a-g) to show digits (0-9). This ensures the number shown on the display always matches the counter value.

4- LED Flip Indicator

Each time the counter transitions to a new number:

. The LED triggered ON (or toggled) to indicate a flip occurred.

This LED acts as counter clock is functioning properly.

5-Clocks and Control signals

The counter requires:

. clock input to drive counting.

. UP/DOWN input to choose direction.

. Reset input to force the counter back to zero.

Truth table

UP Mode = (1)

Current state	Q3 Q2 Q1 Q0	Next state	Q3` Q2` Q1` Q0	LED
0	0 0 0 0	1	0 0 0 1	1
1	0 0 0 1	2	0 0 1 0	1
2	0 0 1 0	3	0 0 1 1	1
3	0 0 1 1	4	0 1 0 0	1
4	0 1 0 0	5	0 1 0 1	1
5	0 1 0 1	6	0 1 1 0	1
6	0 1 1 0	7	0 1 1 1	1
7	0 1 1 1	8	1 0 0 0	1
8	1 0 0 0	9	1 0 0 1	1
9	1 0 0 1	0	0 0 0 0	1

DOWN Mode = (0)

Current state	Q3 Q2 Q1 Q0	Next state	Q3` Q2` Q1` Q0`	LED
0	0 0 0 0	9	1 0 0 1	1
1	0 0 0 1	0	0 0 0 0	1
2	0 0 1 0	1	0 0 0 1	1
3	0 0 1 1	2	0 0 1 0	1
4	0 1 0 0	3	0 0 1 1	1
5	0 1 0 1	4	0 1 0 0	1
6	0 1 1 0	5	0 1 0 1	1
7	0 1 1 1	6	0 1 1 0	1
8	1 0 0 0	7	0 1 1 1	1
9	1 0 0 0	8	1 0 0 0	1

Case UP

On logic works

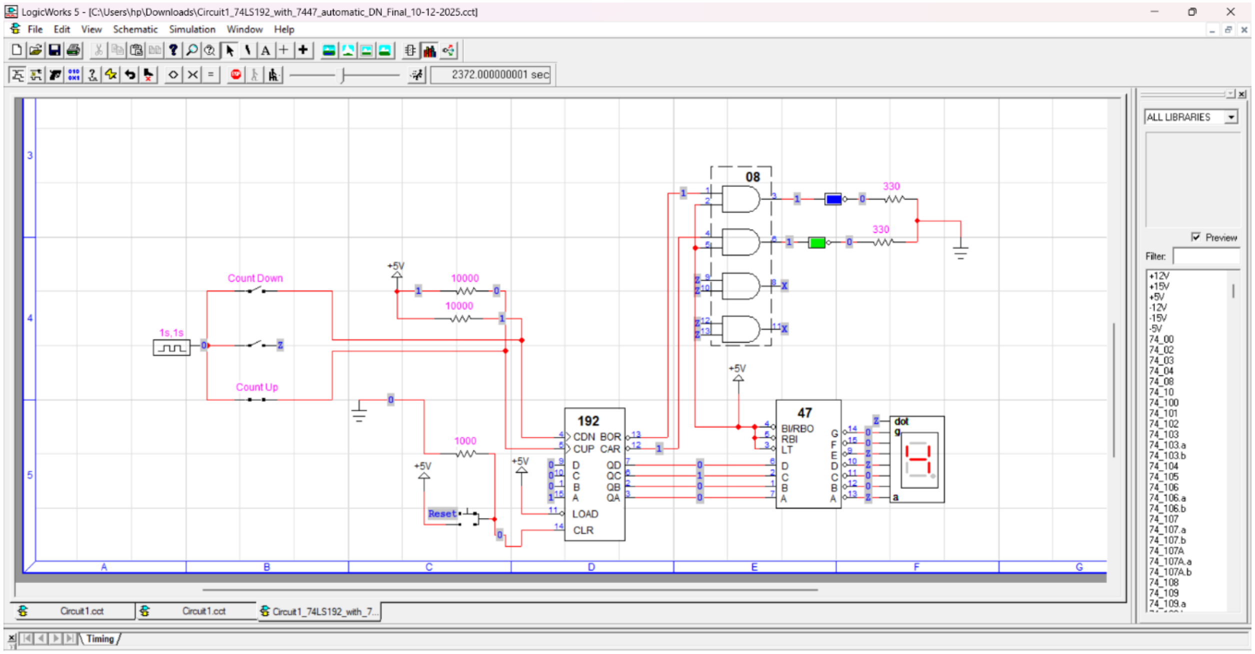

Figure 1-count up on logic works

On hardware

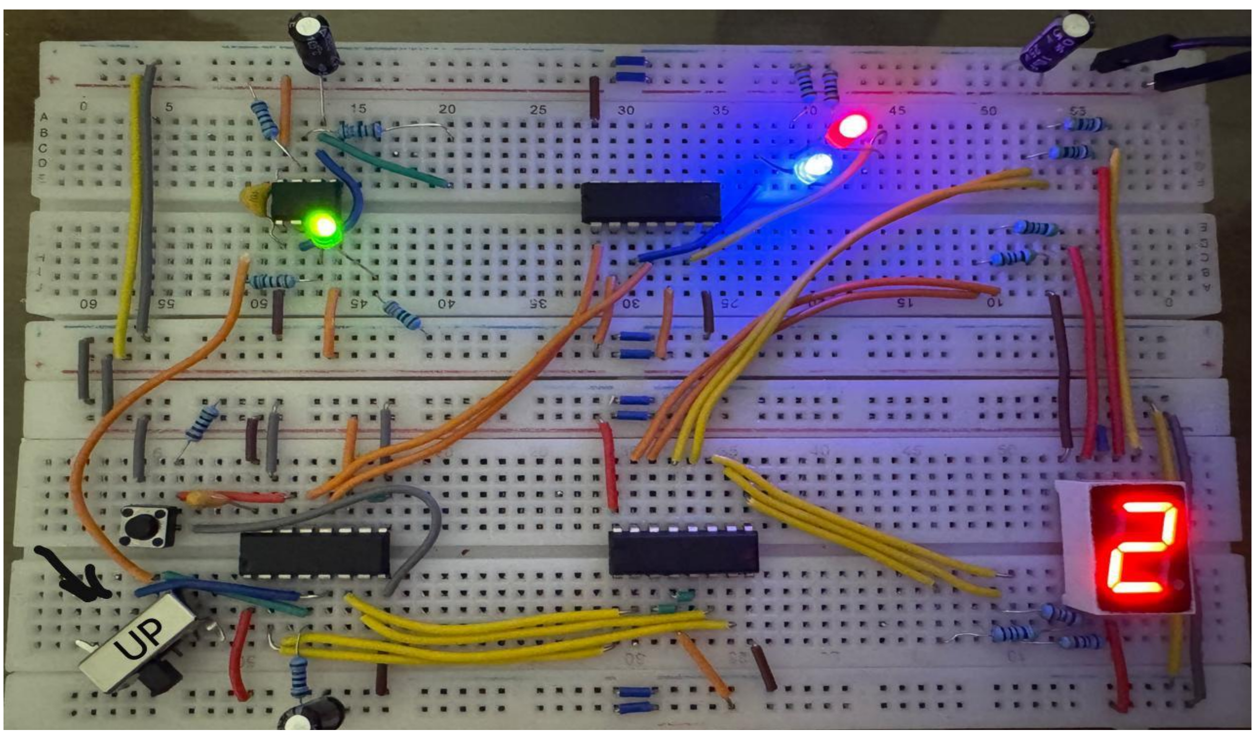

Figure 2-count up on hardware

Case stable

On logic works

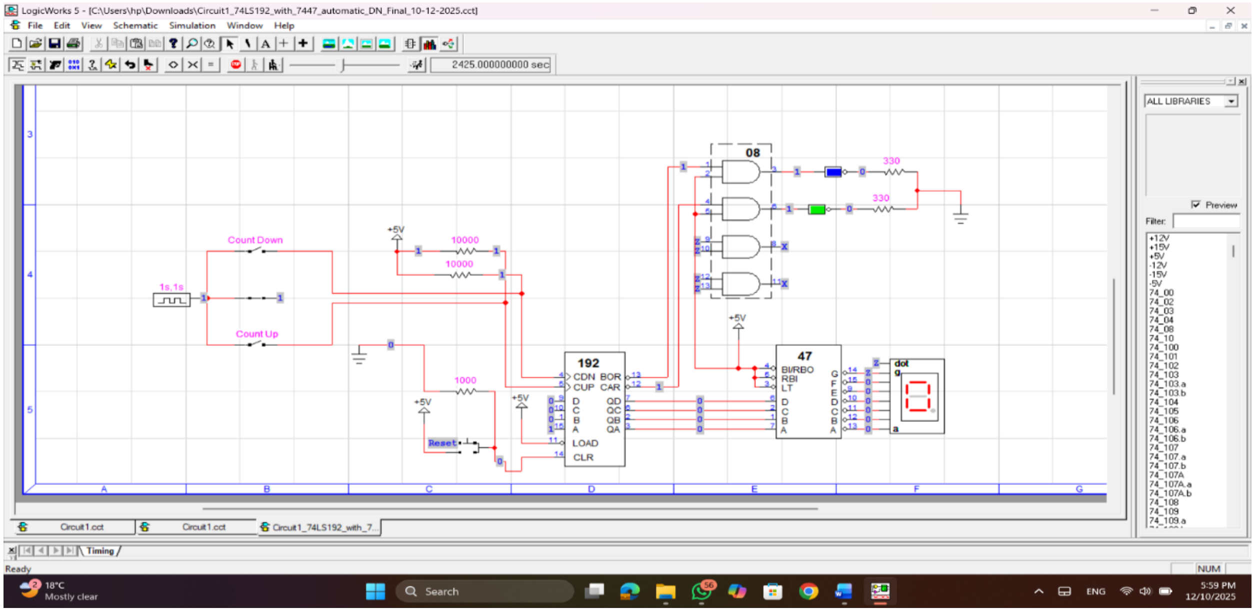

Figure 3-stable state on logic works

On hardware

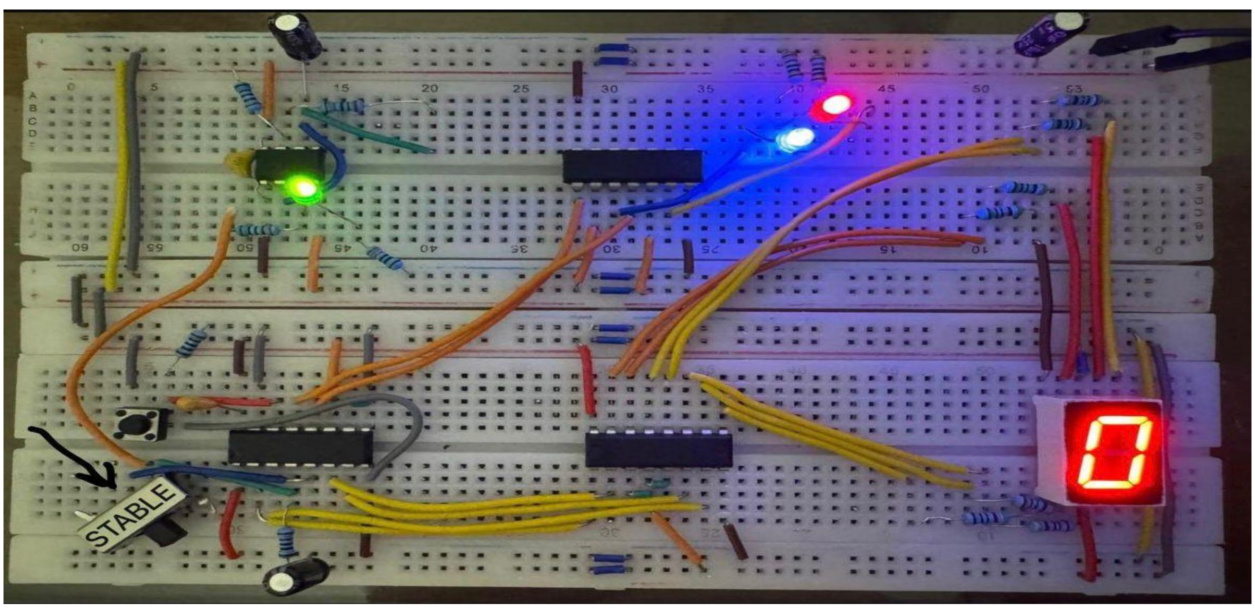

Figure 4-stable state on hardware

Case DOWN

On logic works

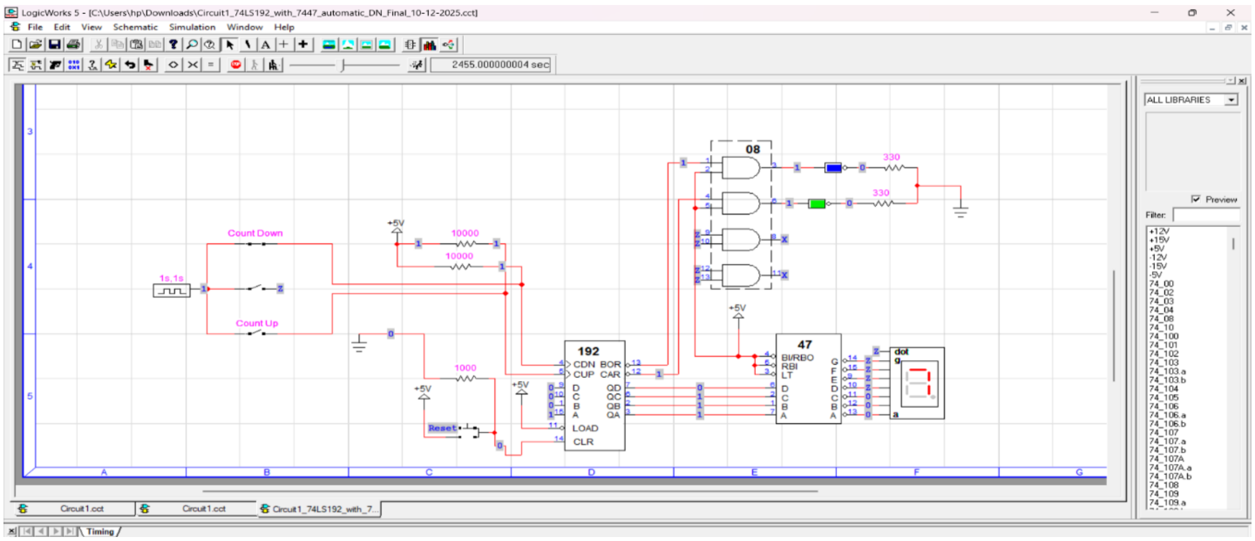

Figure 5-count down on logic works

On hardware

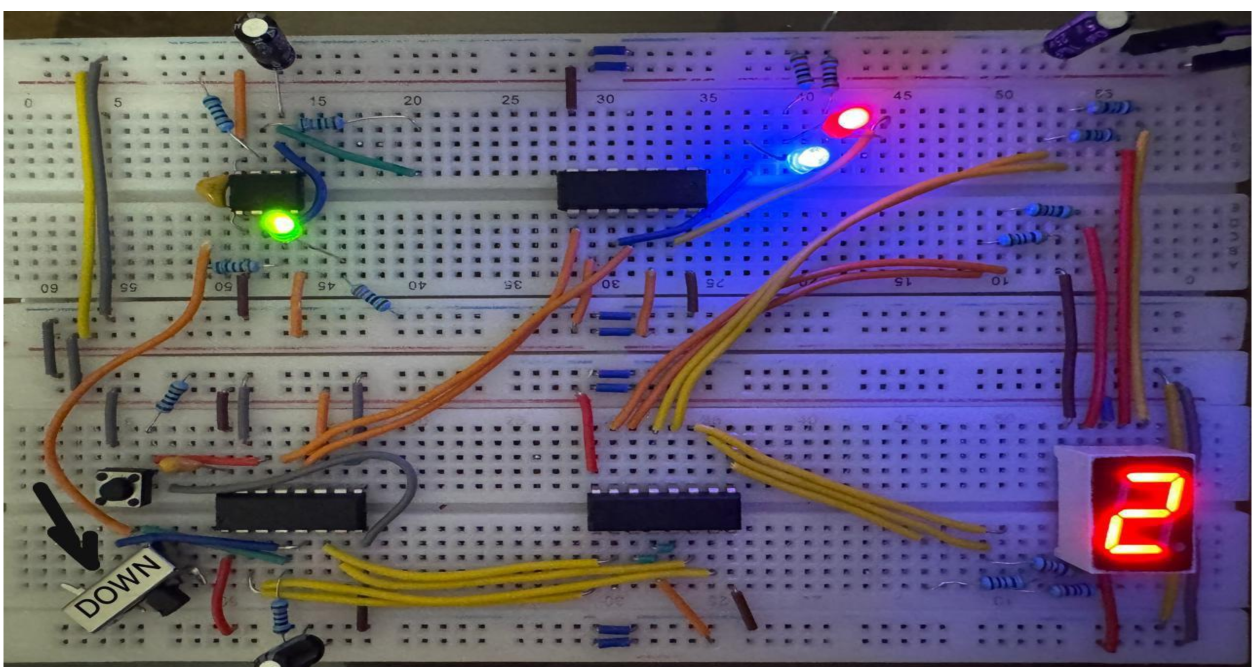

Figure 6-count down on hardware

Comments

1- The project clearly demonstrates how digital counting works by allowing the circuit to move smoothly between counting up and counting down in BCD format.

2- Displaying the output on a 7-segment display makes the operation easy to follow and gives a visual, real-time understanding of how each bit changes.

3- Adding an LED that turns ON every time the counter flips give an intuitive indicator of state changes and makes debugging easier.

4- The project highlights the importance of synchronizing clock pulses and ensuring stable transitions between BCD states.

5- Overall, the design is simple, interactive, and practical—showing how digital logic, displays, and indicators work together in real applications.