

Cruise Speed Control Simulation - Truth Tables

Solution 1: Two 74LS192 BCD up/down counters, 74LS48 common-cathode display drivers, 74LS85 comparator, relay/transistor stage and NE555 flashing red warning LED

This truth-table pack is based on the uploaded Proteus circuit figure. The project conditions are: electronic components only, no microcontroller, no PLC, green for speeds 0-5, amber/yellow for speeds 6-9, flashing red when the selected cruise speed is reached, maximum speed display of 10, and automatic cruise reset logic rather than relying only on a manual reset button.

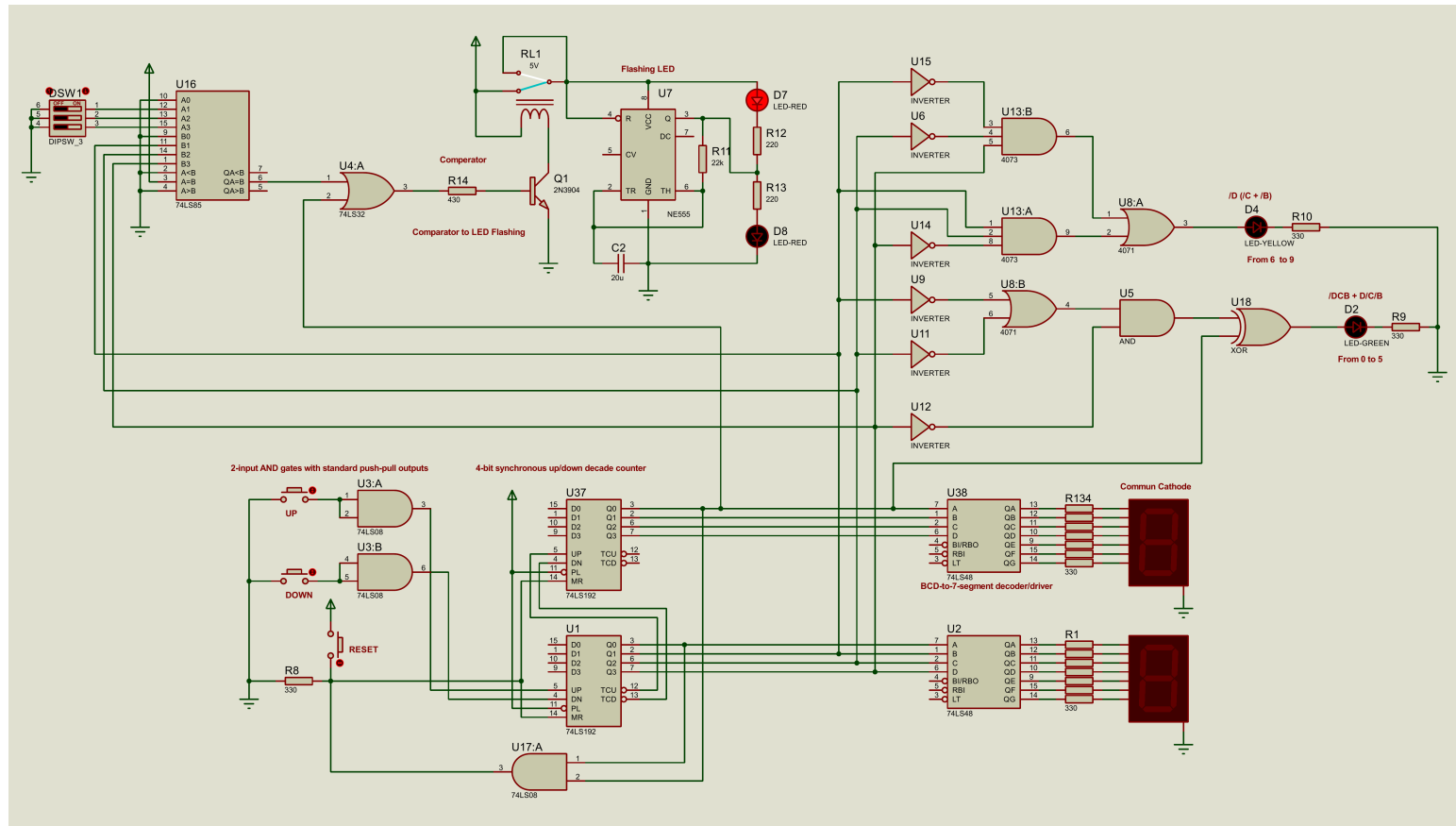


Figure 1: Two-counter cruise speed control solution using 74LS192 counters, 74LS48 display drivers, 74LS85 comparator, NE555 flashing circuit, and green/yellow range indicator logic.

1. Circuit Interpretation and Required Outputs

The circuit displays speed using two common-cathode seven-segment displays. The unit counter displays 0-9 and the tens counter is used to show the maximum value 10. The 74LS85 comparator checks the selected cruise speed against the current speed. When the current speed is equal to or higher than the selected set speed, the comparator output enables the transistor/relay/NE555 stage and the red LED flashes.

Notation used in the tables: A = LSB, B = second BCD bit, C = third BCD bit, D = MSB. T = tens display enable/BCD bit used when the tens display shows 1.

Table 1: Main component function table

Component / label	Part	Function in this solution
U1	74LS192	Unit BCD up/down decade counter. Counts the unit digit from 0 to 9.
U37	74LS192	Tens BCD up/down decade counter. Used to display the tens digit for the maximum value 10.
U2	74LS48	BCD-to-seven-segment decoder/driver for the unit common-cathode display.
U38	74LS48	BCD-to-seven-segment decoder/driver for the tens common-cathode display.
U3:A, U3:B, U17:A	74LS08 AND gates	Gate the UP/DOWN pulses and support reset/count limiting logic.
U4:A	74LS32 OR gate	Combines comparator outputs to form the warning enable signal.
U16	74LS85	4-bit comparator. Compares current BCD speed value with the selected cruise speed value.
DSW1	DIP switch	Manual set-speed input for the comparator.
U5, U6, U8, U9, U11, U12, U13, U14, U15, U18	Logic gates	Produce green and yellow range signals for 0-5 and 6-9.
Q1	2N3904	Transistor driver for relay/NE555 enable stage.
RL1	5 V relay	Switches or enables the flashing LED path when warning condition is active.
U7	NE555	Astable timer used to flash the red warning LEDs.
D2, D4, D7, D8	LED indicators	Green, yellow, and red warning indication.

Table 2: Required operating conditions

Condition	Required output
Current speed = 0 to 5	Green LED ON, yellow LED OFF. Red LED depends only on comparator set speed.
Current speed = 6 to 9	Yellow/amber LED ON, green LED OFF. Red LED depends only on comparator set speed.
Current speed reaches selected set speed	Comparator output F = 1 and red LED flashes through the NE555 stage.
Current speed = 10	Maximum speed is displayed as 10. Red flashing remains active if set speed is 6-9.
Attempted count beyond 10	Logic reset condition is generated so the system does not continue to 11, 12, etc.

2. Counter, Display and Control Truth Tables

The counter section uses two 74LS192 BCD decade counters and two 74LS48 common-cathode display drivers. The unit display counts normally from 0 to 9. The tens display is used to show 1 when the maximum speed 10 is reached.

Table 3: UP/DOWN/RESET operation table

UP push button	DOWN push button	RESET input	Counter action	Display result
0	0	0	Hold	Same value remains displayed
1 pulse	0	0	Count up	Display increases by 1
0	1 pulse	0	Count down	Display decreases by 1
1	1	0	Invalid / avoid	UP and DOWN together may cause incorrect operation
X	X	1	Reset active	Display returns to 00

Table 4: 74LS192 BCD counter truth table for one digit

Decimal digit	D	C	B	A	BCD D C B A
0	0	0	0	0	0000
1	0	0	0	1	0001
2	0	0	1	0	0010
3	0	0	1	1	0011
4	0	1	0	0	0100
5	0	1	0	1	0101
6	0	1	1	0	0110
7	0	1	1	1	0111
8	1	0	0	0	1000
9	1	0	0	1	1001

Table 5: 74LS192-to-74LS48 connection table

Counter output	Logic name	74LS48 input	Purpose
Q0	A / LSB	A	Least significant BCD bit
Q1	B	B	Second BCD bit
Q2	C	C	Third BCD bit
Q3	D / MSB	D	Most significant BCD bit

3. Seven-Segment Display Truth Tables

The 74LS48 is used with common-cathode displays. Therefore, in the segment-output table, 1 means the segment is ON and 0 means the segment is OFF.

Table 6: 74LS48 common-cathode display truth table

Decimal	BCD D C B A	a	b	c	d	e	f	g	Pattern a b c d e f g	Display
0	0000	1	1	1	1	1	1	0	1111110	0
1	0001	0	1	1	0	0	0	0	0110000	1
2	0010	1	1	0	1	1	0	1	1101101	2
3	0011	1	1	1	1	0	0	1	1111001	3
4	0100	0	1	1	0	0	1	1	0110011	4
5	0101	1	0	1	1	0	1	1	1011011	5
6	0110	1	0	1	1	1	1	1	1011111	6
7	0111	1	1	1	0	0	0	0	1110000	7
8	1000	1	1	1	1	1	1	1	1111111	8
9	1001	1	1	1	1	0	1	1	1111011	9

Table 7: Two-display count sequence from 00 to maximum speed 10

Speed displayed	Tens D C B A	Unit D C B A	Valid state	Reset_11 signal	Meaning
00	0000	0000	Valid	0	Normal display
01	0000	0001	Valid	0	Normal display
02	0000	0010	Valid	0	Normal display
03	0000	0011	Valid	0	Normal display
04	0000	0100	Valid	0	Normal display
05	0000	0101	Valid	0	Normal display
06	0000	0110	Valid	0	Normal display
07	0000	0111	Valid	0	Normal display
08	0000	1000	Valid	0	Normal display
09	0000	1001	Valid	0	Normal display
10	0001	0000	Valid	0	Maximum speed displayed
11	0001	0001	Invalid	1	Automatic reset returns display to 00

Reset limiting equation used for the table: $\text{Reset_11} = \text{Tens_A} \cdot \text{Unit_A}$. This detects the first invalid state after maximum speed 10 and forces the counters back to 00.

4. Green and Yellow Indicator Logic

The green/yellow range LEDs must follow the project requirement rather than the decimal-display segment pattern. The logic below uses the BCD output of the unit counter and inhibits the range LEDs when the tens display is 1, so the maximum speed 10 is handled separately by the warning logic.

Green = NOT T . NOT D . (NOT C + NOT B)

Yellow = NOT T . [(NOT D . C . B) + (D . NOT C . NOT B)]

Table 8: Green/yellow speed range truth table

Speed	T	Unit D	Unit C	Unit B	Unit A	Green LED	Yellow LED	Range meaning
0	0	0	0	0	0	1	0	0-5: Green / safe range
1	0	0	0	0	1	1	0	0-5: Green / safe range
2	0	0	0	1	0	1	0	0-5: Green / safe range
3	0	0	0	1	1	1	0	0-5: Green / safe range
4	0	0	1	0	0	1	0	0-5: Green / safe range
5	0	0	1	0	1	1	0	0-5: Green / safe range
6	0	0	1	1	0	0	1	6-9: Yellow / higher range
7	0	0	1	1	1	0	1	6-9: Yellow / higher range
8	0	1	0	0	0	0	1	6-9: Yellow / higher range
9	0	1	0	0	1	0	1	6-9: Yellow / higher range
10	1	0	0	0	0	0	0	10: Maximum speed, warning handled by red LED

Table 9: Gate-level LED logic implementation table

Logic block	Inputs	Gate / part	Output
Invert D, C, B	D, C, B from unit counter	Inverters	NOT D, NOT C, NOT B
Green range OR	NOT C, NOT B	OR gate	NOT C + NOT B
Green range AND	NOT T, NOT D, OR output	AND gate	Green = 1 for 0-5
Yellow term 1	NOT T, NOT D, C, B	AND gate	Y1 = 1 for 6 and 7
Yellow term 2	NOT T, D, NOT C, NOT B	AND gate	Y2 = 1 for 8 and 9
Final yellow	Y1, Y2	OR gate	Yellow = 1 for 6-9

5. Comparator and Flashing Red Warning Truth Tables

The 74LS85 comparator output is used to trigger the flashing red warning stage. The warning enable signal is made by OR-ing the A>B and A=B outputs.

$$F = (\text{Current speed} > \text{Set speed}) + (\text{Current speed} = \text{Set speed})$$

Table 10: 74LS85 comparator output truth table

Current speed condition	A>B	A=B	A<B	F	Red flashing LED
Current speed < Set speed	0	0	1	0	OFF
Current speed = Set speed	0	1	0	1	Flashing
Current speed > Set speed	1	0	0	1	Flashing

Table 11: DIP-switch set-speed BCD table

Set speed	D	C	B	A	BCD D C B A	Comparator meaning
6	0	1	1	0	0110	Red flashes when current speed >= 6
7	0	1	1	1	0111	Red flashes when current speed >= 7
8	1	0	0	0	1000	Red flashes when current speed >= 8
9	1	0	0	1	1001	Red flashes when current speed >= 9

Design note: for set speeds 8 and 9, the comparator B3/MSB line must be available and driven HIGH as shown in the BCD table.

Table 12: Comparator matrix for current speed 0 to 10

Current speed	Set 6	Set 7	Set 8	Set 9	Red LED summary
0	0	0	0	0	OFF for set speeds 6-9
1	0	0	0	0	OFF for set speeds 6-9
2	0	0	0	0	OFF for set speeds 6-9
3	0	0	0	0	OFF for set speeds 6-9
4	0	0	0	0	OFF for set speeds 6-9
5	0	0	0	0	OFF for set speeds 6-9
6	1	0	0	0	Flashing only if set = 6
7	1	1	0	0	Flashing if set = 6 or 7
8	1	1	1	0	Flashing if set = 6, 7 or 8
9	1	1	1	1	Flashing for set speeds 6-9
10	1	1	1	1	Flashing for set speeds 6-9

6. NE555 Flashing Stage and Final Operating Summary

The comparator output F drives the 2N3904 transistor and relay/enable path. When F is LOW, the 555 timer is disabled and the red LED remains OFF. When F is HIGH, the 555 astable circuit is enabled and the red warning LED flashes.

Table 13: NE555 flashing red LED operation truth table

F from comparator	Q1 transistor	Relay / enable path	NE555 state	Red LED output
0	OFF	Not energised / disabled	RESET low or disabled	OFF
1	ON	Energised / enabled	Astable mode active	Flashing

Table 14: Final complete operating truth table

Displayed speed	Green	Yellow	Comparator result	Red flashing	System meaning
00	ON	OFF	Depends on selected set speed	Normally OFF if set speed is 6-9	Low/safe speed range
01	ON	OFF	Depends on selected set speed	Normally OFF if set speed is 6-9	Low/safe speed range
02	ON	OFF	Depends on selected set speed	Normally OFF if set speed is 6-9	Low/safe speed range
03	ON	OFF	Depends on selected set speed	Normally OFF if set speed is 6-9	Low/safe speed range
04	ON	OFF	Depends on selected set speed	Normally OFF if set speed is 6-9	Low/safe speed range
05	ON	OFF	Depends on selected set speed	Normally OFF if set speed is 6-9	Low/safe speed range
06	OFF	ON	F=1 when speed >= set speed	OFF or Flashing depending on set speed	Higher cruise-speed range
07	OFF	ON	F=1 when speed >= set speed	OFF or Flashing depending on set speed	Higher cruise-speed range
08	OFF	ON	F=1 when speed >= set speed	OFF or Flashing depending on set speed	Higher cruise-speed range
09	OFF	ON	F=1 when speed >= set speed	OFF or Flashing depending on set speed	Higher cruise-speed range
10	OFF	OFF	F=1 for set speeds 6-9	Flashing	Maximum speed displayed

Final summary: The two-counter solution shows the current speed from 00 to 10. Green indicates 0-5, yellow indicates 6-9, and the red LED flashes when the current speed reaches or passes the selected cruise speed. The 11-detection reset prevents the display from continuing beyond the required maximum speed range.