Cruise Speed Control Simulation - Truth Tables

CD4029 two-counter solution with 74LS47 common-anode displays, 74LS85 comparator and NE555 flashing red warning

This document summarises the truth tables for the uploaded Project.PDF circuit. The design is treated as an electronic-component solution only: no microcontroller and no PLC are used. The required operating ranges are green for speeds 0 to 5, amber/yellow for speeds 6 to 9, and flashing red when the selected cruise speed has been reached. The display must also show the maximum speed of 10.

Figure 1 shows the circuit used as the reference for these truth tables.

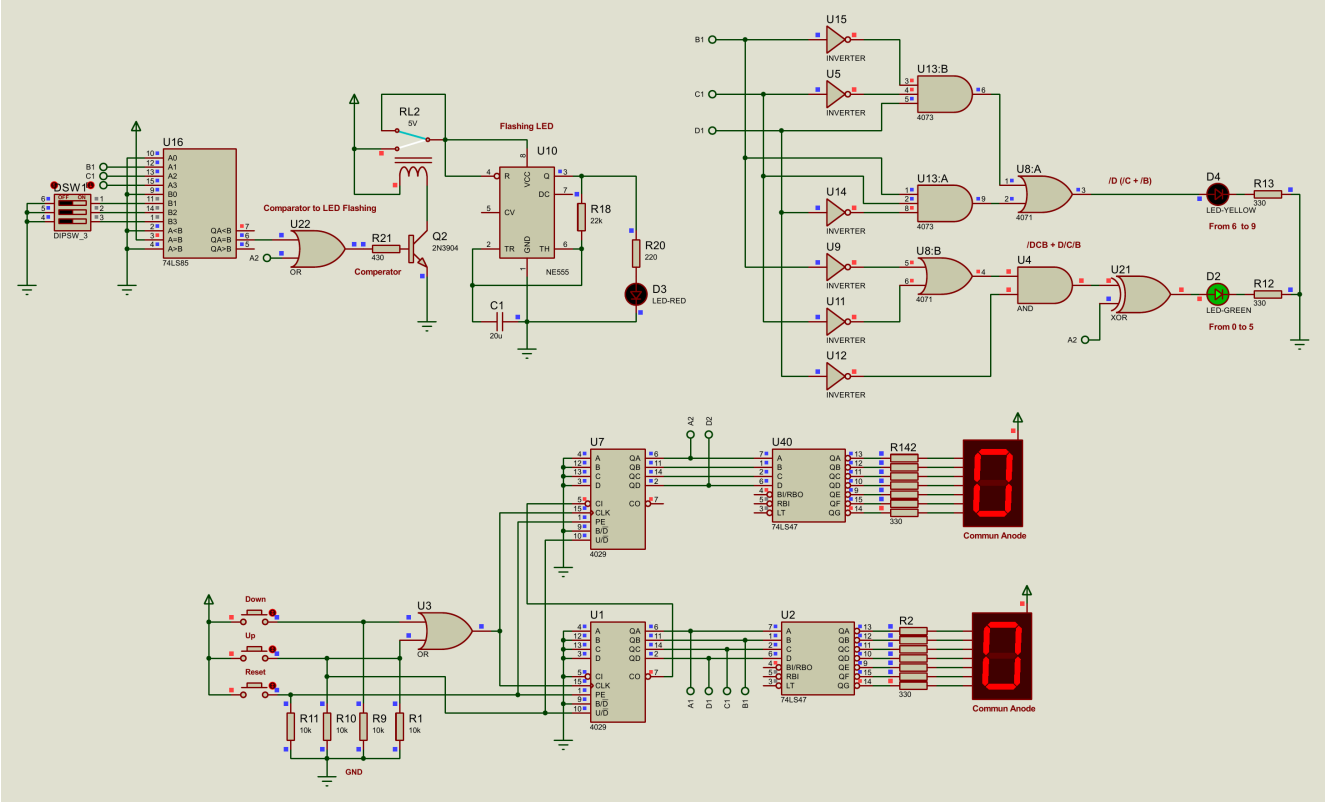

Figure 1: CD4029, 74LS47, 74LS85 and NE555 cruise speed control circuit used for the truth tables.

1. Circuit operating comment

The circuit uses two CD4029 counters to produce a two-digit speed display. The unit counter displays 0 to 9 and the tens counter allows the circuit to show 10. The BCD outputs are decoded by 74LS47 drivers for common-anode seven-segment displays. The LED logic uses the BCD signals from the unit counter and the tens signal A2 to separate the ranges 0-5 and 6-9, while keeping green OFF at the maximum speed of 10. The 74LS85 comparator checks the current speed against the selected cruise speed. When the current speed is equal to or greater than the set speed, the NE555 flashing circuit is enabled and the red LED flashes.

2. Main component function table

Component / label	Circuit part	Purpose in this solution
U1	CD4029	Unit BCD up/down counter. Counts the unit digit 0 to 9.
U7	CD4029	Tens BCD counter. Used so the display can show 10.
U2, U40	74LS47	BCD-to-seven-segment decoder/driver for common-anode displays.
7-segment displays	Common-anode	Shows the current speed value on two digits.
U3	OR gate	Combines UP and DOWN push-button pulses into a clock pulse.
U5, U6, U9, U11, U12, U14, U15	Inverters	Generate NOT B1, NOT C1, NOT D1 and other complemented signals used by the LED logic.
U13:A, U13:B	CD4073 AND gates	Create the yellow range terms for 6-7 and 8-9.
U8:A, U8:B	CD4071 OR gates	Combine LED logic terms.
U4 and U21	AND / XOR logic	Final green LED logic. The tens signal A2 is used to keep green OFF at 10.

Component / label	Circuit part	Purpose in this solution
U16	74LS85	Compares the displayed current speed with the selected cruise set speed.
DSW1	DIP switch	Manual set-speed input for the comparator.
U22, Q2, RL2	OR gate, transistor and relay	Enable the red flashing section when the comparator condition is reached.
U10	NE555	Astable flashing circuit for the red warning LED.

3. CD4029 counter pin and connection table

CD4029 pin	Label	Connection / use in this design
15	CLK	Clock pulse from UP/DOWN logic through U3.
10	U/D	Selects count direction: UP for increasing speed and DOWN for decreasing speed.
9	B/D	Set for decade/BCD counting mode.
1	PE	Preset enable. Held inactive during normal counting.
5	CI	Carry/count-enable input for normal single-stage or cascaded operation.
6	QA / A	Least significant BCD output. Goes to 74LS47 input A and logic labels A1/A2.
11	QB / B	Second BCD output. Goes to 74LS47 input B and LED/comparator logic.
14	QC / C	Third BCD output. Goes to 74LS47 input C and LED/comparator logic.
2	QD / D	Most significant BCD output. Goes to 74LS47 input D and LED/comparator logic.
7	CO	Carry output used for cascading the unit counter to the tens counter.

4. UP, DOWN and reset control truth table

DOWN	UP	RESET / cruise reset	Clock from U3	Direction	Counter action	Display result
0	0	0	0	Previous state	Hold	Same value remains displayed
0	1 pulse	0	1 pulse	Up	Count up	Display increases by 1
1 pulse	0	0	1 pulse	Down	Count down	Display decreases by 1
1	1	0	1	Invalid	Not recommended	May behave incorrectly
X	X	1	X	X	Reset / clear	Display returns to 00

5. CD4029 BCD counter truth table

For each counter, the BCD outputs are defined as A = QA/LSB, B = QB, C = QC and D = QD/MSB. The table below shows the standard decade count used by the unit digit.

Decimal	D	C	B	A	BCD DCBA
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

6. 74LS47 common-anode seven-segment truth table

For a 74LS47 driving a common-anode display, 0 means the segment output is active/ON and 1 means the segment output is OFF.

Decimal	BCD DCBA	a	b	c	d	e	f	g	Display
0	0000	0	0	0	0	0	0	1	0
1	0001	1	0	0	1	1	1	1	1
2	0010	0	0	1	0	0	1	0	2
3	0011	0	0	0	0	1	1	0	3
4	0100	1	0	0	1	1	0	0	4
5	0101	0	1	0	0	1	0	0	5
6	0110	0	1	0	0	0	0	0	6
7	0111	0	0	0	1	1	1	1	7
8	1000	0	0	0	0	0	0	0	8
9	1001	0	0	0	0	1	0	0	9

7. Two-display 00 to 10 operating truth table

This table links the two CD4029 counters to the displayed speed and to the required green/yellow indicator outputs.

Speed	Tens DCBA	Unit DCBA	Tens display	Unit display	A2	Green	Yellow	State
0	0000	0000	0	0	0	1	0	0-5 green
1	0000	0001	0	1	0	1	0	0-5 green
2	0000	0010	0	2	0	1	0	0-5 green
3	0000	0011	0	3	0	1	0	0-5 green
4	0000	0100	0	4	0	1	0	0-5 green
5	0000	0101	0	5	0	1	0	0-5 green
6	0000	0110	0	6	0	0	1	6-9 yellow
7	0000	0111	0	7	0	0	1	6-9 yellow
8	0000	1000	0	8	0	0	1	6-9 yellow
9	0000	1001	0	9	0	0	1	6-9 yellow
10	0001	0000	1	0	1	0	0	Max speed 10

8. Green and yellow LED range logic

The unit counter signals are labelled A1, B1, C1 and D1. A1 is the least significant unit bit and D1 is the most significant unit bit. The tens signal A2 is used to identify the displayed value 10.

Yellow = (NOT D1 . C1 . B1) + (D1 . NOT C1 . NOT B1)

Low-range base = NOT D1 . (NOT C1 + NOT B1)

Final Green = Low-range base XOR A2

The XOR with A2 keeps the green LED ON for 0-5, but OFF when the display reaches 10.

Speed	A2	Unit DCBA	Low-range base	Yellow	Final green	LED result
0	0	0000	1	0	1	Green ON
1	0	0001	1	0	1	Green ON
2	0	0010	1	0	1	Green ON
3	0	0011	1	0	1	Green ON
4	0	0100	1	0	1	Green ON
5	0	0101	1	0	1	Green ON
6	0	0110	0	1	0	Yellow ON
7	0	0111	0	1	0	Yellow ON
8	0	1000	0	1	0	Yellow ON
9	0	1001	0	1	0	Yellow ON
10	1	0000	1	0	0	No green/yellow; red warning at max

9. 74LS85 comparator truth table

The comparator output used for the red flashing stage is F = (A > B) + (A = B), where A represents the current speed and B represents the selected set speed.

Current speed condition	A > B	A = B	A < B	F = (A>B)+(A=B)	Red LED state
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

10. DIP switch set-speed table

The selected cruise speed can be set on the comparator input. The most important cruise set values for this project are 6 to 9, with 10 treated as the maximum displayed speed.

Set speed	D	C	B	A	BCD DCBA	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
10	1	0	0	0	A2=1, unit=0000	Maximum speed indication; red remains active if set speed has been reached

11. Example comparator operation table

Set speed	Current speed	Comparator result	F	Red LED
6	5	Current < Set	0	OFF
6	6	Current = Set	1	Flashing
6	9	Current > Set	1	Flashing
8	7	Current < Set	0	OFF
8	8	Current = Set	1	Flashing
9	8	Current < Set	0	OFF
9	9	Current = Set	1	Flashing
9	10	Current > Set	1	Flashing

12. NE555 flashing red LED truth table

F from comparator	Q2 transistor	Relay RL2 / NE555 reset	NE555 state	Red LED
0	OFF	Relay not energised / reset inactive	Disabled	OFF
1	ON	Relay energised / reset released	Astable flashing	Flashing

13. Maximum-speed and automatic reset truth table

The system must be able to show 10. After 10, the counter should not continue into invalid speeds. Therefore, the reset/range-control logic must allow 10 to be displayed and then force the next invalid state back to 00. This is the cruise reset function, not just a normal push-button reset.

Detected count	Tens A2	Unit A1	Action	Reason
00 to 09	0	0/1	Normal counting	Valid speed range before maximum
10	1	0	Hold/show maximum speed	The project requires the maximum speed 10 to be displayed
11	1	1	Automatic reset to 00	Prevents the system from counting above the required maximum
Manual RESET	X	X	Initialises the circuit	Used for starting/testing, not the cruise reset function

14. Final operating summary

Condition	Green	Yellow	Flashing red	Meaning
Speed 0 to 5	ON	OFF	Depends on comparator	Low/normal speed range
Speed 6 to 9	OFF	ON	Depends on comparator	Higher speed range before maximum
Speed = selected set speed	Range LED works	Range LED works	Flashing	Cruise speed has been reached
Speed > selected set speed	Range LED works	Range LED works	Flashing	Speed has passed set speed
Speed = 10	OFF	OFF	Flashing if comparator active	Maximum speed displayed
Speed attempts to go above 10	OFF	OFF	Reset/controlled	Automatic reset prevents invalid display