

New Project Cruise Speed Control - Truth Tables

CD4029 counters, CD4511 common-cathode displays, 74LS85 comparator and NE555 flashing warning

This truth-table pack is based on the uploaded New Project circuit. The solution is treated as an electronic circuit implementation only, without a microcontroller and without PLC control. The required display and indicators are: green for speeds 0 to 5, amber/yellow for speeds 6 to 9, flashing red when the selected cruise speed has been reached, and a visible maximum speed of 10.

The figure is introduced before the tables because it is the reference schematic for the logic names and component labels used in the document.

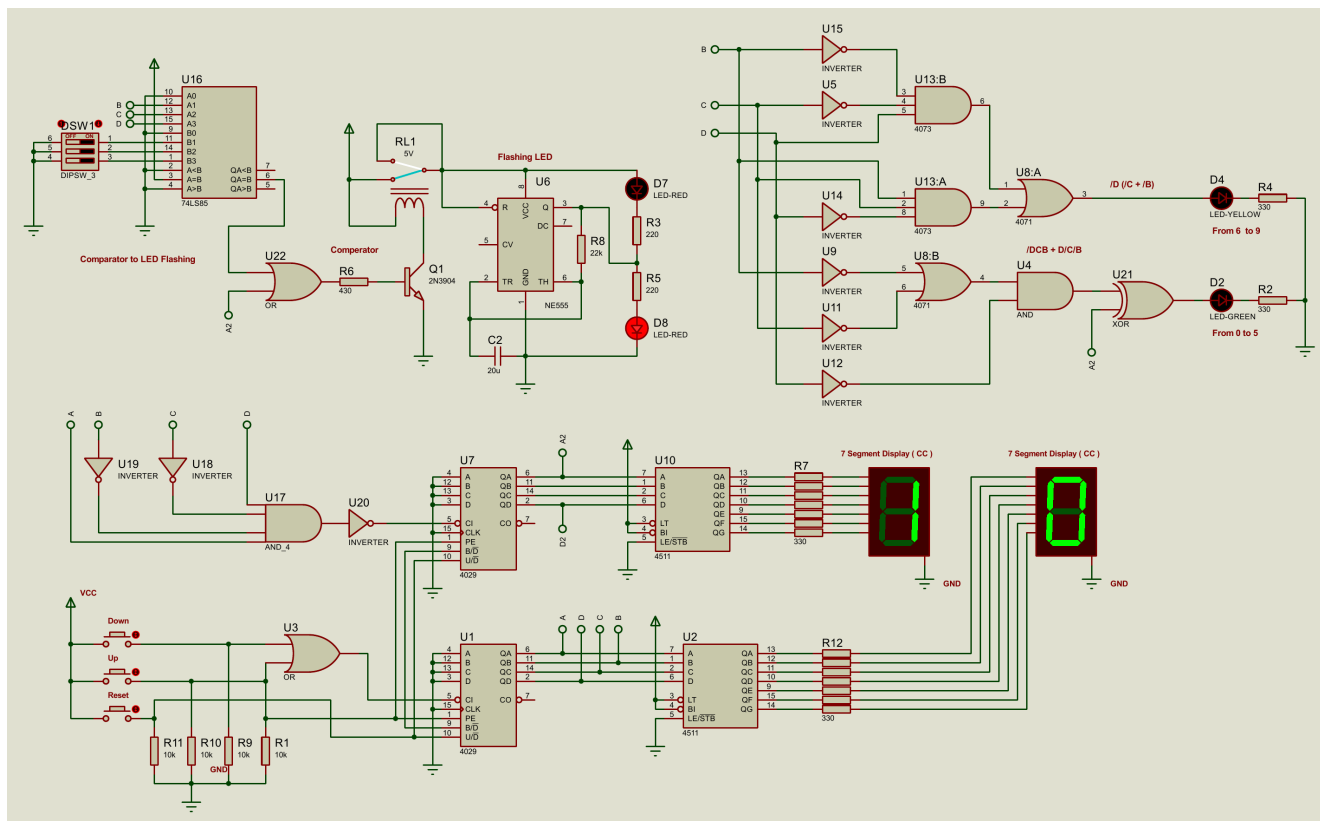


Figure 1: New Project CD4029 and CD4511 cruise speed control solution used for the truth tables.

1. Circuit comment

The circuit uses two CD4029 up/down counters. The unit counter handles the unit digit and the tens counter allows the display to reach 10. The CD4511 drivers convert the BCD outputs into seven-segment signals for common-cathode displays, where a logic 1 turns a segment ON. The BCD outputs are also reused by the green/yellow logic. A2 is the tens signal used to recognise the maximum speed condition. The 74LS85 comparator checks whether the current speed has reached or passed the selected cruise speed, and the NE555 circuit produces the flashing red warning.

Logic notation used in the tables: / means NOT, adjacency or . means AND, and + means OR.

2. Component and connection tables

Table 1: Main component function table

Component / label	Circuit part	Purpose in this solution
U1	CD4029	Unit BCD up/down counter. Provides the unit digit of the current speed.
U7	CD4029	Tens BCD counter. Allows the two-display system to show the maximum speed 10.
U2, U10	CD4511	BCD-to-seven-segment latch/decoder/driver for common-cathode displays.
Displays	7-segment common cathode	Show the current speed as two digits: tens and units.
U3	OR gate	Combines UP and DOWN pulses into one clock line for the counter stage.
U13:A, U13:B	CD4073 AND gates	Generate the yellow-range logic terms for 6-7 and 8-9.
U8:A, U8:B	CD4071 OR gates	Combine LED logic terms.
U4	AND gate	Forms the low-range green base condition before the maximum-speed correction.
U5, U9, U11, U12, U14, U15	Inverters	Create /B, /C and /D logic signals for the LED range equations.

Component / label	Circuit part	Purpose in this solution
U21	XOR gate	Uses A2 to switch green OFF when the display reaches 10.
U16	74LS85	Compares current speed with the selected cruise set speed from the DIP switch.
DSW1	DIP switch	Manual set-speed reference input for the comparator.
U22, Q1, RL1	OR gate, 2N3904 and relay	Enable path for the red flashing warning circuit.
U6	NE555	Astable flashing circuit for the red LED warning.

Table 2: Important connection and signal table

Device	Pin / signal	Connection / use
CD4029 U1	QA, QB, QC, QD	Unit BCD outputs A, B, C, D to CD4511 U2 and LED/comparator logic.
CD4029 U7	QA / A2	Tens output used to show 10 and to disable green at maximum speed.
CD4029	CLK	Clock pulses from the UP/DOWN input network.
CD4029	U/D	Direction control for increasing or decreasing speed.
CD4029	B/D	Set for BCD/decade counting mode.
CD4511 U2	A, B, C, D inputs	Receives unit BCD code from U1.
CD4511 U10	A, B, C, D inputs	Receives tens BCD code from U7.
CD4511	QA to QG	Segment outputs through 330 ohm resistors to common-cathode displays.
74LS85 U16	QA>B, QA=B	ORed to form comparator warning signal F.
NE555 U6	RESET / enable path	Activated through transistor/relay when warning enable is HIGH.

3. Counter control and BCD counting

Table 3: UP, DOWN and RESET operation table

DOWN	UP	RESET	Clock from U3	Direction	Counter action	Display result
0	0	0	0	Previous	Hold	Same speed remains displayed
0	1 pulse	0	1 pulse	UP	Count up	Speed increases by 1
1 pulse	0	0	1 pulse	DOWN	Count down	Speed decreases by 1
1	1	0	1	Invalid	Not recommended	May behave incorrectly
X	X	1	X	X	Manual clear	Display returns to 00

Table 4: CD4029 BCD output truth table for one 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

4. CD4511 common-cathode display truth table

The CD4511 is used with common-cathode displays. Therefore, the segment outputs are active HIGH: 1 means the segment is ON and 0 means the segment is OFF.

Table 5: CD4511 seven-segment truth table

Display digit	BCD DCBA	a	b	c	d	e	f	g	Segment note
0	0000	1	1	1	1	1	1	0	1 = ON
1	0001	0	1	1	0	0	0	0	1 = ON
2	0010	1	1	0	1	1	0	1	1 = ON
3	0011	1	1	1	1	0	0	1	1 = ON
4	0100	0	1	1	0	0	1	1	1 = ON
5	0101	1	0	1	1	0	1	1	1 = ON
6	0110	1	0	1	1	1	1	1	1 = ON
7	0111	1	1	1	0	0	0	0	1 = ON

Display digit	BCD DCBA	a	b	c	d	e	f	g	Segment note
8	1000	1	1	1	1	1	1	1	1 = ON
9	1001	1	1	1	1	0	1	1	1 = ON

5. Two-display speed truth table

The project requirement is to show a maximum speed of 10. For speeds 00 to 09, the tens display remains 0. At speed 10, the tens display becomes 1 and the unit display returns to 0.

Table 6: Display and range truth table for 00 to 10

Speed	Tens display	Units display	Tens A2	Unit DCBA	Green	Yellow	Red warning condition
00	0	0	0	0000	1	0	Only if set speed <= current speed
01	0	1	0	0001	1	0	Only if set speed <= current speed
02	0	2	0	0010	1	0	Only if set speed <= current speed
03	0	3	0	0011	1	0	Only if set speed <= current speed
04	0	4	0	0100	1	0	Only if set speed <= current speed
05	0	5	0	0101	1	0	Only if set speed <= current speed
06	0	6	0	0110	0	1	Flashes if cruise set speed reached
07	0	7	0	0111	0	1	Flashes if cruise set speed reached
08	0	8	0	1000	0	1	Flashes if cruise set speed reached
09	0	9	0	1001	0	1	Flashes if cruise set speed reached
10	1	0	1	0000	0	0	Flashing at maximum speed

6. Green and yellow LED range logic

Base Yellow = $(/D \cdot C \cdot B) + (D \cdot /C \cdot /B)$

Base Green = $/D \cdot (/C + /B)$

Final Green = Base Green XOR A2

Final Yellow = Base Yellow

A2 is included in the final green logic so that the green LED turns OFF at speed 10. The yellow equation naturally remains OFF at 10 because the unit digit is 0.

Table 7: Full green/yellow truth table from 00 to 10

Speed	A2	Unit DCBA	Base green $/D(/C+/B)$	Base yellow $/DCB + D/C/B$	Final green	Final yellow	Indicator result
00	0	0000	1	0	1	0	Green ON
01	0	0001	1	0	1	0	Green ON
02	0	0010	1	0	1	0	Green ON
03	0	0011	1	0	1	0	Green ON
04	0	0100	1	0	1	0	Green ON
05	0	0101	1	0	1	0	Green ON
06	0	0110	0	1	0	1	Yellow ON
07	0	0111	0	1	0	1	Yellow ON
08	0	1000	0	1	0	1	Yellow ON
09	0	1001	0	1	0	1	Yellow ON
10	1	0000	1	0	0	0	Green OFF, yellow OFF; max-speed red warning

7. Comparator and set-speed truth tables

The 74LS85 output used for the warning is $F = (A > B) + (A = B)$. Therefore, the red warning starts when the current speed is equal to or greater than the selected cruise speed.

Table 8: 74LS85 comparator truth table

Current speed condition	A > B	A = B	A < B	$F = (A > B) + (A = B)$	Red 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 9: DIP switch set-speed reference table

Set speed	Tens bit A2	D	C	B	A	Reference code	Meaning
6	0	0	1	1	0	0 0110	Red flashes when current speed $\geq$ 6
7	0	0	1	1	1	0 0111	Red flashes when current speed $\geq$ 7
8	0	1	0	0	0	0 1000	Red flashes when current speed $\geq$ 8
9	0	1	0	0	1	0 1001	Red flashes when current speed $\geq$ 9
10	1	0	0	0	0	1 0000	Maximum-speed indication; red warning remains active

Table 10: Example comparator operation table

Set speed	Current speed	Comparator result	F	A2	Warning enable	Red LED
6	5	Current < Set	0	0	0	OFF
6	6	Current = Set	1	0	1	Flashing
6	9	Current > Set	1	0	1	Flashing
8	7	Current < Set	0	0	0	OFF
8	8	Current = Set	1	0	1	Flashing
9	8	Current < Set	0	0	0	OFF
9	9	Current = Set	1	0	1	Flashing
9	10	Current > Set / max	1	1	1	Flashing

8. Red flashing LED and cruise reset

The red warning enable is treated as: Warning Enable = F + A2. This means the red LED flashes when the comparator condition is reached, and it also remains active at the maximum-speed condition of 10.

Table 11: NE555 flashing red warning truth table

Comparator F	Tens A2	Warning enable = F + A2	Q1 transistor	Relay / NE555	Red LED
0	0	0	OFF	Disabled	OFF
1	0	1	ON	Enabled	Flashing
0	1	1	ON	Enabled by maximum-speed signal	Flashing
1	1	1	ON	Enabled	Flashing

Table 12: Cruise reset and maximum-speed truth table

Condition	Detected signal	Cruise reset output	Display action	Comment
Speed 00 to 09	A2 = 0	0	Normal counting	Valid speeds before maximum
Speed 10	A2 = 1 and units = 0000	0	Show 10	Maximum speed must be visible
Next invalid count after 10	Logic detects count above maximum	1	Return to 00	This is the logic-based cruise reset, not the normal reset button
Manual RESET button	User presses reset	1	Return to 00	Used for testing or initialising only

9. Final operating summary

Condition	Green	Yellow	Flashing red	Display
Speed 00 to 05	ON	OFF	Depends on comparator set speed	00-05
Speed 06 to 09	OFF	ON	Depends on comparator set speed	06-09
Current speed < set speed	Range LED works	Range LED works	OFF	Current speed
Current speed = set speed	Range LED works	Range LED works	Flashing	Current speed
Current speed > set speed	Range LED works	Range LED works	Flashing	Current speed
Speed 10	OFF	OFF	Flashing	10
Count above 10	OFF	OFF	Reset path active	Returns to 00

Final note: the normal push-button reset is included for initialising or testing the circuit. The cruise reset required by the project is represented by the logic-based reset action that prevents operation above the required maximum speed.