Updated CD4029 + CD4511 Cruise Speed Control Truth Tables

Includes the forced carry/borrow at 09 circuit and the XOR green-LED OFF correction

The uploaded New Project.PDF solution uses two CD4029 counters, two CD4511 common-cathode display drivers, a 74LS85 comparator, gate logic, an NE555 flashing red LED stage, and extra logic for carry/borrow and green LED correction.

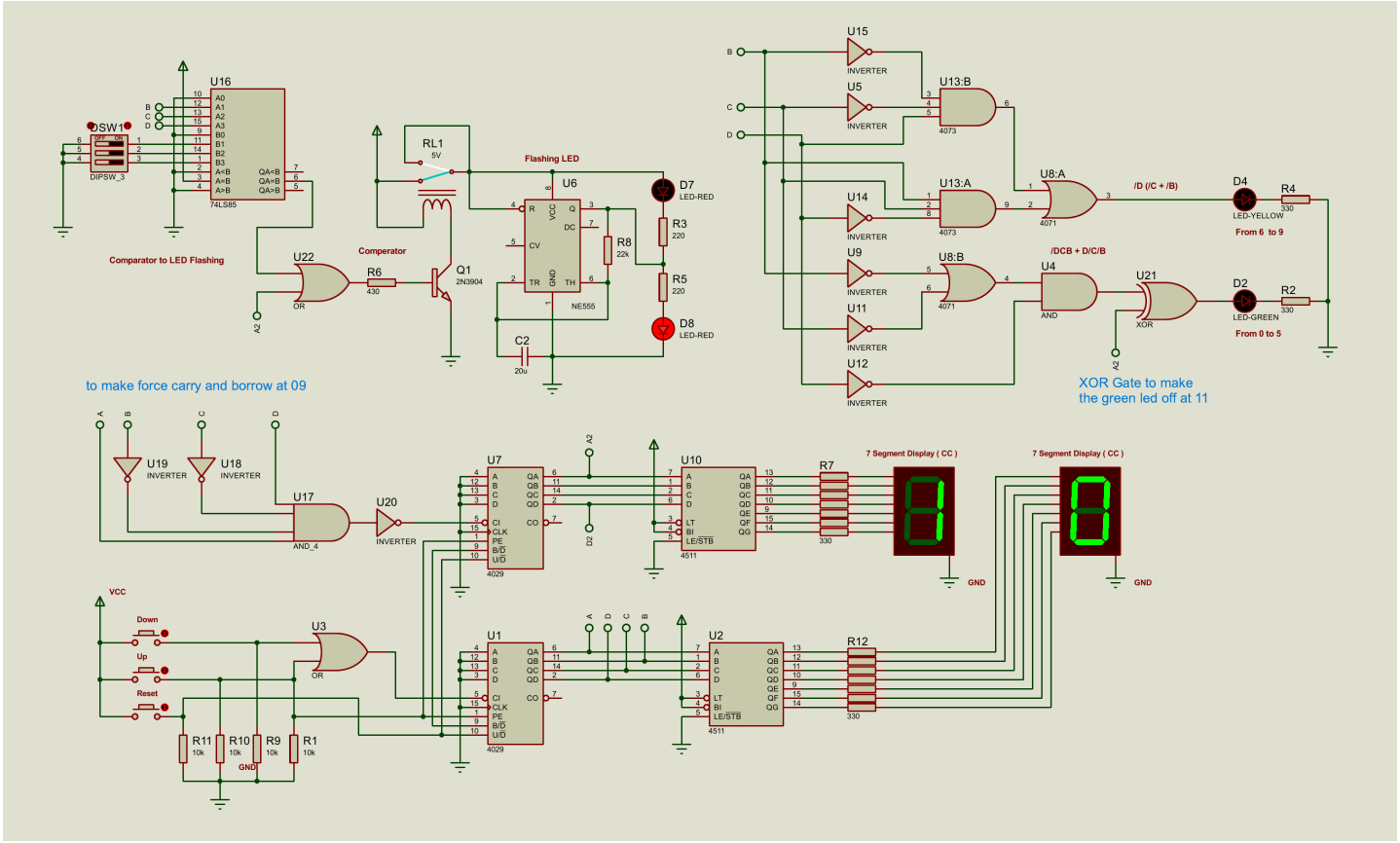
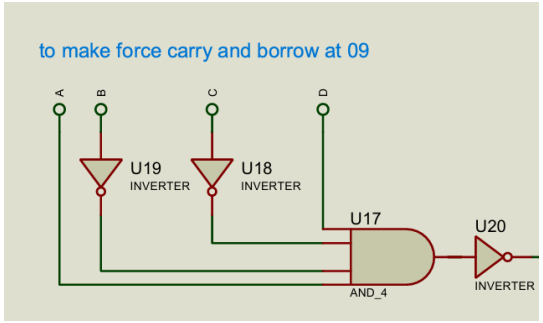


Figure 1: Updated New Project circuit with CD4029 counters, CD4511 display drivers, green/yellow range logic, comparator warning, NE555 flashing red LED stage, forced carry/borrow logic, and XOR green correction.



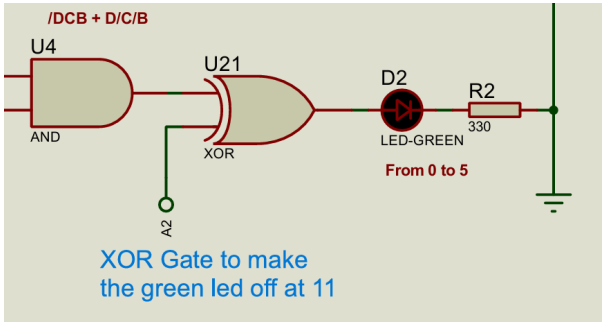


Figure 2: Added details. Left: force carry and borrow at 09 using the 9-detection gate. Right: XOR gate correction used to make the green LED OFF at 11/high two-digit state.

1. Added Design Notes Included

Added item	Meaning in the truth tables
Force carry and borrow at 09	The added logic detects the unit digit 9 using A . NOT B . NOT C . D. This creates a 09 detect signal used to force or control carry/borrow around the 09 boundary.
U20 inverter after the AND_4 gate	The 9-detect signal is inverted where an active-low carry/borrow control is required by the counter stage.
XOR gate for green LED	The raw green output is corrected using A2 so that the green LED is not ON during the two-digit high state, especially 11 as marked in the figure.
Valid project range	The intended displayed range remains 00 to 10. The 11 state is treated as an invalid/high state that must not be allowed as a normal operating speed.

2. Main Component Function Table

Component / label	Part	Function in this solution
U1 and U7	CD4029	Unit and ten BCD up/down counters.
U2 and U10	CD4511	BCD-to-seven-segment latch/decoder/driver for common-cathode displays.
U17, U18, U19, U20	AND_4 and inverters	Detect unit digit 9 and force carry/borrow at 09.
U21	XOR gate	Corrects the green LED output so it is OFF during the high/two-digit state.
U4, U8:A, U8:B, U13:A, U13:B	AND/OR/4073 logic	Generate green/yellow range logic.
U16	74LS85	Compares selected cruise speed with current speed.
DSW1	DIPSW_3	Manual cruise speed set input.
Q1, RL1, U6	2N3904, relay, NE555	Enable and flash the red warning LED when set speed is reached.

3. CD4029 BCD Counter Truth Table

The CD4029 BCD outputs are treated as A = QA, B = QB, C = QC, and D = QD. A is the least significant bit and D is the most significant bit.

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

4. CD4511 Common-Cathode Display Truth Table

For the CD4511 driving a common-cathode display, 1 means the segment is ON and 0 means the segment is OFF. Segment order is a b c d e f g.

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

5. 00 to 10 Operating Truth Table

Speed	Ten BCD	Unit BCD	Ten display	Unit display	Green	Yellow	Meaning
00	0000	0000	0	0	1	0	Green range
01	0000	0001	0	1	1	0	Green range
02	0000	0010	0	2	1	0	Green range
03	0000	0011	0	3	1	0	Green range
04	0000	0100	0	4	1	0	Green range
05	0000	0101	0	5	1	0	Green range
06	0000	0110	0	6	0	1	Amber/yellow range
07	0000	0111	0	7	0	1	Amber/yellow range
08	0000	1000	0	8	0	1	Amber/yellow range
09	0000	1001	0	9	0	1	Amber/yellow range
10	0001	0000	1	0	0	0	Maximum speed displayed; green/yellow OFF

6. Force Carry / Borrow at 09 Truth Table

Detect 09 unit digit: N9 = A . NOT B . NOT C . D

Inverted control after U20: NOT N9

This detection is HIGH only when the unit counter is at 9, which is the boundary where the two-display counter must create a carry on upward counting or a borrow boundary on downward counting.

Unit digit	D	C	B	A	N9 = A./B./C.D	U20 output = NOT N9	Function
0	0	0	0	0	0	1	Normal count
1	0	0	0	1	0	1	Normal count
2	0	0	1	0	0	1	Normal count
3	0	0	1	1	0	1	Normal count
4	0	1	0	0	0	1	Normal count
5	0	1	0	1	0	1	Normal count
6	0	1	1	0	0	1	Normal count
7	0	1	1	1	0	1	Normal count
8	1	0	0	0	0	1	Normal count
9	1	0	0	1	1	0	Force carry/borrow boundary

7. Green / Yellow Logic With XOR Correction

Yellow = (NOT D . C . B) + (D . NOT C . NOT B)

Raw Green = NOT Yellow

Corrected Green = Raw Green XOR A2

A2 is the two-digit/high-state correction input. When A2 becomes active in the high state, the XOR gate prevents the raw green signal from turning the green LED ON incorrectly.

Speed	D	C	B	A	A2	Yellow	Raw Green	Corrected Green	Final output
00	0	0	0	0	0	0	1	1	Green ON
01	0	0	0	1	0	0	1	1	Green ON
02	0	0	1	0	0	0	1	1	Green ON
03	0	0	1	1	0	0	1	1	Green ON
04	0	1	0	0	0	0	1	1	Green ON
05	0	1	0	1	0	0	1	1	Green ON
06	0	1	1	0	0	1	0	0	Yellow ON
07	0	1	1	1	0	1	0	0	Yellow ON
08	1	0	0	0	0	1	0	0	Yellow ON
09	1	0	0	1	0	1	0	0	Yellow ON
10	0	0	0	0	1	0	1	0	Both OFF at max
11	0	0	0	1	1	0	1	0	Invalid/high state: Green OFF

8. UP / DOWN / Reset Control Truth Table

UP	DOWN	Manual RESET	Carry/borrow force	Counter action	Display result
0	0	0	0	Hold	Same number remains displayed.
1 pulse	0	0	0	Count up	Display increases by 1.
1 pulse at 09	0	0	1	Force carry	Ten counter increments and display moves to 10.
0	1 pulse	0	0	Count down	Display decreases by 1.
0	1 pulse at boundary	0	1	Force borrow	Counter handles the two-digit boundary correctly.
1	1	0	X	Invalid/avoid	UP and DOWN together is not recommended.
X	X	1	X	Manual reset	Display returns to 00.

9. Automatic Maximum-Speed / High-State Limit Table

Display state	Valid?	Action
00 to 08	Valid	Normal counting.
09	Valid boundary	Force carry/borrow logic becomes ready.
10	Valid maximum	Maximum speed is displayed.
11	Invalid/high state	XOR correction keeps green OFF; reset/limit logic should clear or block this state.
99	Invalid/high state	High-state protection must reset or prevent continued counting.

10. 74LS85 Comparator Truth Table

The comparator output enables the red flashing LED when the current speed reaches or passes the selected cruise speed.

F = (Current speed > Set speed) + (Current speed = Set speed)

Current speed condition	QA>B	QA=B	QA<B	F	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

DIP switch set-speed table:

Set speed	BCD D C B A	Meaning
6	0110	Red flashes when current speed >= 6
7	0111	Red flashes when current speed >= 7
8	1000	Red flashes when current speed >= 8
9	1001	Red flashes when current speed >= 9
10	1010	Red flashes when current speed >= 10

11. NE555 Flashing Red LED Truth Table

Comparator output F	Q1 / relay stage	NE555 state	Red LED state
0	OFF	Disabled or held reset	OFF
1	ON	Enabled astable mode	Flashing

12. Final Operating Summary

Condition	Green LED	Yellow LED	Red flashing LED	Display behaviour
Speed 00-05	ON	OFF	Depends on comparator set speed	Normal lower-speed range.
Speed 06-09	OFF	ON	Depends on comparator set speed	Amber/yellow range.
Speed 09 boundary	OFF	ON	Depends on comparator set speed	Force carry/borrow logic becomes active for the next transition.
Speed 10	OFF	OFF	Flashing if selected speed has been reached	Maximum speed displayed.
Speed 11 / high state	OFF by XOR correction	OFF	Depends after reset	Invalid/high state; reset/limit logic must clear or block.