

CD40110 Two-Display Cruise Speed Control Solution

Truth tables, LED range logic, comparator decision logic, automatic limit reset, and flashing red warning operation

Source solution: One Counter.PDF circuit figure. The circuit uses electronic components only: two CD40110 counters, common-cathode seven-segment displays, 74LS85 comparators, gate logic, a transistor/relay stage, and an NE555 flashing red LED stage.

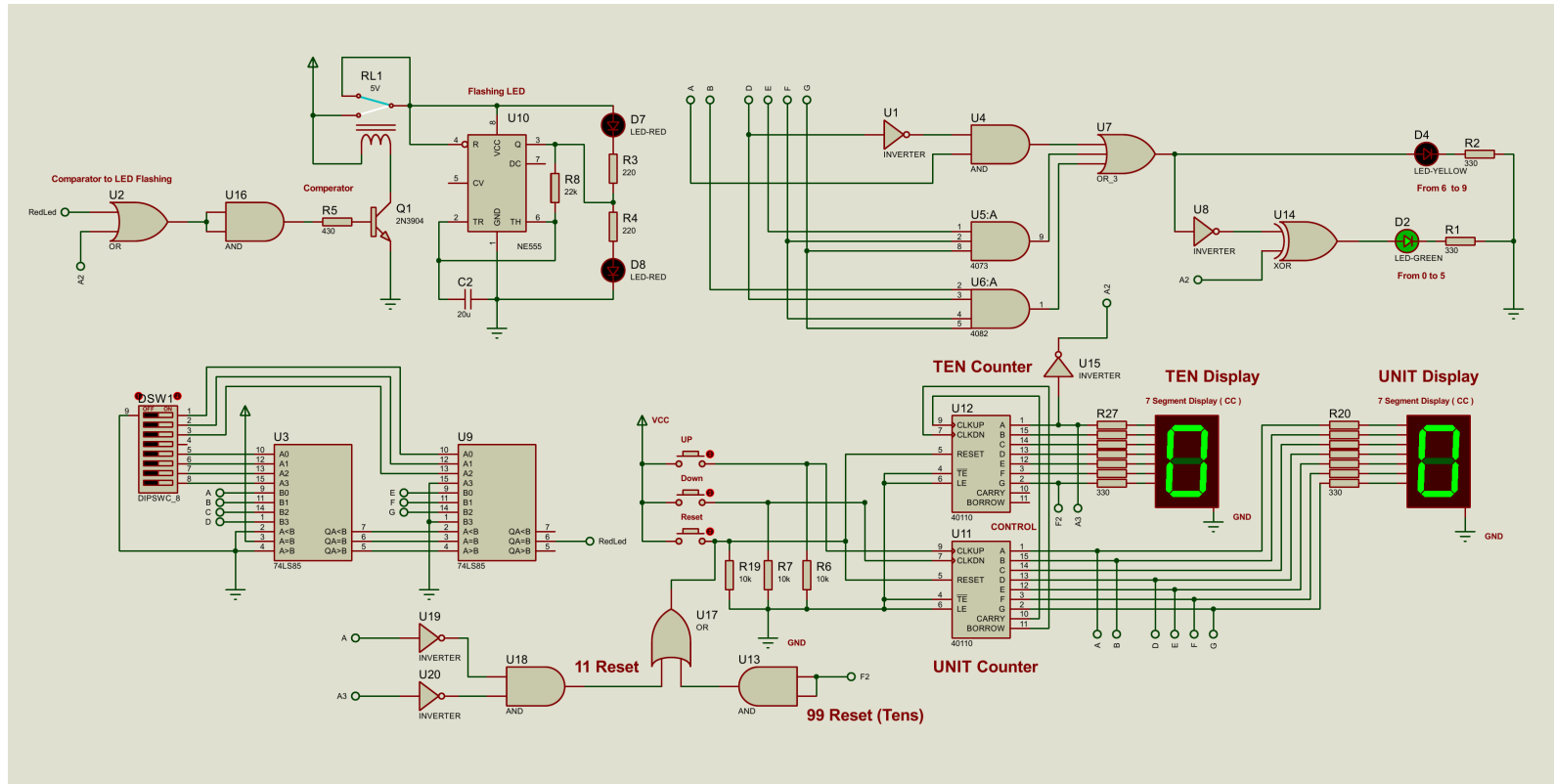


Figure 1: Two-CD40110 cruise speed control circuit with unit counter, ten counter, range LEDs, comparator stage, NE555 flashing red LED, and reset limiting logic.

Important working assumptions used for these truth tables: the CD40110 display outputs are active-HIGH because the displays are common-cathode; the display sequence is limited to 00 to 10; an attempted 11 state activates the automatic limit reset; and the red LED flashing circuit is enabled when the comparator output indicates that the current speed has reached or exceeded the selected cruise speed.

1. Main Component Function Table

Component / label	Part used in the figure	Function in this solution
U11	CD40110	Unit counter. Counts the unit digit and directly drives the unit common-cathode seven-segment display.
U12	CD40110	Ten counter. Displays the ten digit so the system can show 10 as the maximum speed.
Unit display	7-segment common cathode	Shows the unit digit from the unit CD40110.
Ten display	7-segment common cathode	Shows the ten digit. It remains 0 for 00-09 and becomes 1 at 10.
UP / DOWN / Reset buttons	Push buttons with 10 kOhm pull-downs	Generate count-up, count-down, and manual display reset inputs.
U1, U4, U5:A, U6:A, U7	Inverter, AND gates, OR gate	Create the yellow/amber range signal from the CD40110 segment outputs.
U8 and U14	Inverter and XOR gate	Create the corrected green signal and prevent green from remaining ON at 10.
U3 and U9	74LS85 comparators	Compare the current speed with the selected cruise speed from the DIP switch stage.
DSW1	8-bit DIP switch	Provides the selected cruise-speed input to the comparator section.
U2 and U16	OR and AND gates	Combine comparator signals to create the red-warning enable path.
Q1 and RL1	2N3904 and 5 V relay	Drive or isolate the NE555 flashing LED stage when the comparator enables warning.
U10	NE555 timer	Astable flashing circuit for the red LED warning.
D4 / D2 / D7-D8	Yellow, green, and red LEDs	Yellow indicates 06-09, green indicates 00-05, and red flashes when cruise speed is reached.

2. Overall Signal Flow Table

Stage	Signal path	Meaning
Counting and display	UP / DOWN / Reset -> U11 CD40110 -> unit display; U11 carry/borrow -> U12 CD40110 -> ten display	Displays the current simulated speed as 00 to 10.
Range indication	Unit CD40110 segment outputs A, B, D, E, F, G -> logic gates -> yellow and green LEDs	Separates 00-05 from 06-09 and blocks green at 10.
Comparator decision	Current speed signals and DIP switch set-speed signals -> U3/U9 74LS85 comparator stage	Checks whether the current speed has reached or passed the selected cruise value.
Red warning	Comparator output -> OR/AND gate -> Q1/relay -> NE555 RESET/enable -> red LED	Red LED flashes when current speed is equal to or greater than set speed.
Automatic limit reset	Invalid 11 detection/reset logic -> reset path	Allows 10 to be displayed as maximum, then resets/limits the next invalid count.

3. CD40110 Pin Connection Table Used for Unit and Ten Counters

CD40110 pin	Label	Connection / use in this circuit	Meaning
9	CLKUP	UP button/cascade clock-up line	Counts upward when pulsed.
7	CLKDN	DOWN button/cascade clock-down line	Counts downward when pulsed.
5	RESET	Manual reset and automatic limit reset path	Clears the display output.
4	TE	Enable/control line	Counter enable / terminal-enable control.
6	LE	Latch-enable/control line	Controls output latching.
1	A	Segment A and logic input A	Top segment output.
15	B	Segment B and logic input B	Upper-right segment output.
14	C	Segment C	Lower-right segment output.
13	D	Segment D and logic input D	Bottom segment output.
12	E	Segment E and logic input E	Lower-left segment output.
3	F	Segment F and logic input F	Upper-left segment output.
2	G	Segment G and logic input G	Middle segment output.
10	CARRY	Cascade output	Used when the unit digit passes 9 during count-up.
11	BORROW	Cascade output	Used when the unit digit passes 0 during count-down.

4. UP, DOWN, and Reset Operation Truth Table

UP button	DOWN button	Manual Reset button	Automatic limit reset	Counter action	Display result
0	0	0	0	Hold	Same number remains displayed.
1 pulse	0	0	0	Count up	Display increases by 1.
0	1 pulse	0	0	Count down	Display decreases by 1.
1	1	0	0	Avoid	UP and DOWN together is not recommended.
X	X	1	X	Manual reset	Display returns to 00.
X	X	0	1	Automatic limit reset	Invalid state is cleared so the sequence remains limited to 00-10.

5. CD40110 Common-Cathode Display Truth Table

For the CD40110 direct display output, **1 = segment ON** and **0 = segment OFF**. The segment order is A B C D E F G.

Count	A	B	C	D	E	F	G	Pattern ABCDEFG	Displayed digit
0	1	1	1	1	1	1	0	1111110	0
1	0	1	1	0	0	0	0	0110000	1
2	1	1	0	1	1	0	1	1101101	2
3	1	1	1	1	0	0	1	1111001	3
4	0	1	1	0	0	1	1	0110011	4
5	1	0	1	1	0	1	1	1011011	5
6	1	0	1	1	1	1	1	1011111	6
7	1	1	1	0	0	0	0	1110000	7
8	1	1	1	1	1	1	1	1111111	8
9	1	1	1	1	0	1	1	1111011	9

6. Two-Digit Speed Display Truth Table: 00 to 10

Speed	Ten digit	Unit digit	Ten pattern ABCDEFG	Unit pattern ABCDEFG	Visible display	Comment
00	0	0	1111110	1111110	00	Normal 00-05 green range
01	0	1	1111110	0110000	01	Normal 00-05 green range
02	0	2	1111110	1101101	02	Normal 00-05 green range
03	0	3	1111110	1111001	03	Normal 00-05 green range
04	0	4	1111110	0110011	04	Normal 00-05 green range
05	0	5	1111110	1011011	05	Normal 00-05 green range
06	0	6	1111110	1011111	06	Amber/yellow range
07	0	7	1111110	1110000	07	Amber/yellow range
08	0	8	1111110	1111111	08	Amber/yellow range
09	0	9	1111110	1111011	09	Amber/yellow range
10	1	0	0110000	1111110	10	Maximum speed displayed

7. Yellow / Green LED Logic Equations

The unit CD40110 segment outputs are reused as logic inputs. Segment C is not required for this range-detection method.

$$Y1 = A \cdot \text{NOT } D$$

$$Y2 = E \cdot F \cdot G$$

$$Y3 = A \cdot B \cdot F \cdot G$$

$$\text{Yellow} = Y1 + Y2 + Y3$$

$$\text{Green} = (\text{NOT Yellow}) \text{ XOR } T10$$

T10 is the ten-digit active signal. It is 0 for 00-09 and 1 when the display reaches 10. The XOR correction prevents green from turning ON at 10.

Unit digit	Pattern ABCDEFG	Y1=A.NOT D	Y2=E.F.G	Y3=A.B.F.G	Yellow	Raw NOT Yellow
0	1111110	0	0	0	0	1
1	0110000	0	0	0	0	1
2	1101101	0	0	0	0	1
3	1111001	0	0	0	0	1
4	0110011	0	0	0	0	1
5	1011011	0	0	0	0	1
6	1011111	0	1	0	1	0
7	1110000	1	0	0	1	0
8	1111111	0	1	1	1	0
9	1111011	0	0	1	1	0

8. Final Green / Yellow Range Truth Table for 00 to 10

Speed	T10	Unit digit	Unit Yellow	NOT Yellow	Green=(NOT Yellow) XOR T10	Yellow LED	Range meaning
00	0	0	0	1	1	0	00-05: Green ON
01	0	1	0	1	1	0	00-05: Green ON
02	0	2	0	1	1	0	00-05: Green ON
03	0	3	0	1	1	0	00-05: Green ON
04	0	4	0	1	1	0	00-05: Green ON
05	0	5	0	1	1	0	00-05: Green ON
06	0	6	1	0	0	1	06-09: Yellow ON
07	0	7	1	0	0	1	06-09: Yellow ON
08	0	8	1	0	0	1	06-09: Yellow ON
09	0	9	1	0	0	1	06-09: Yellow ON
10	1	0	0	1	0	0	10: Maximum speed; green/yellow OFF, red warning depends on comparator

9. Automatic Maximum-Speed Limit / Reset Truth Table

This section represents the automatic reset/limit function required by the project. It is different from the ordinary manual reset button. The system is allowed to show 10, but the next invalid 11 state must be cleared or blocked.

Present display	UP pulse?	Detected condition	Automatic reset output	Next valid display
00 to 08	1	Normal unit count	0	Current speed + 1
09	1	Unit carry increments ten digit	0	10
10	1	Attempted next state would be 11	1	00 or held below invalid 11
11	X	Invalid state detected	1	00
Any value	X	Manual Reset button = 1	Manual reset active	00

Reset signal / label	Role in the circuit	Truth-table meaning
11 Reset	Detects the invalid 11 limit condition.	HIGH only when the display tries to move beyond the allowed maximum of 10.
99 Reset (Tens)	Protects/controls the ten counter reset path.	Prevents the ten display from continuing into unwanted higher values.
Manual Reset button	User reset input shown in the push-button section.	Returns the displayed speed to 00 independently of the cruise limit logic.

10. Comparator and Red Flashing LED Truth Tables

The comparator stage checks whether the current speed has reached or passed the selected cruise speed. The red flashing enable signal is:

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

Current speed condition	QA>B	QA=B	QA<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

Recommended DIP switch set-speed table for the practical range:

Set speed	Ten BCD D C B A	Unit BCD D C B A	8-bit setting	Meaning
06	0 0 0 0	0 1 1 0	0000 0110	Red flashes when current speed >= 06
07	0 0 0 0	0 1 1 1	0000 0111	Red flashes when current speed >= 07
08	0 0 0 0	1 0 0 0	0000 1000	Red flashes when current speed >= 08
09	0 0 0 0	1 0 0 1	0000 1001	Red flashes when current speed >= 09
10	0 0 0 1	0 0 0 0	0001 0000	Red flashes when current speed >= 10

Example comparator operation table:

Selected set speed	Current speed	Comparator result	F	Red LED state
06	05	Current < Set	0	OFF
06	06	Current = Set	1	Flashing
06	10	Current > Set	1	Flashing
07	06	Current < Set	0	OFF
07	07	Current = Set	1	Flashing
08	07	Current < Set	0	OFF
08	08	Current = Set	1	Flashing
09	08	Current < Set	0	OFF
09	09	Current = Set	1	Flashing
09	10	Current > Set	1	Flashing
10	09	Current < Set	0	OFF
10	10	Current = Set	1	Flashing

11. NE555 Flashing Red LED Operation Table

NE555 pin	Name	Connection / function
1	GND	Ground.
8	VCC	+5 V supply in the shown circuit.
4	RESET / enable	Controlled by the comparator/relay path. HIGH enables flashing.
2	TRIG	Connected in astable timing network.
6	THRESH	Connected to timing capacitor network.
7	DISCH	Connected to timing resistor network.
5	CV	Control-voltage capacitor path.
3	OUT	Flashing output to the red LED path through limiting resistors.

Comparator F	Q1 / relay stage	NE555 state	Red LED state	Meaning
0	OFF / relay not energised	Disabled or held reset	OFF	Current speed is below the selected cruise speed.
1	ON / relay energised	Enabled astable mode	Flashing	Current speed has reached or passed the selected cruise speed.

12. Final Operating Summary Table

Condition	Green LED	Yellow LED	Red flashing LED	Display behaviour
Speed 00-05	ON	OFF	OFF unless set speed is 00-05	Normal low-speed range.
Speed 06-09	OFF	ON	Depends on selected cruise speed	Amber/yellow warning range.
Speed 10	OFF	OFF	Flashing if selected cruise speed has been reached	Maximum speed displayed.
Current speed < Set speed	Range logic works normally	Range logic works normally	OFF	System has not yet reached cruise value.
Current speed = Set speed	Range logic works normally	Range logic works normally	Flashing	Cruise speed reached.
Current speed > Set speed	Range logic works normally	Range logic works normally	Flashing	Cruise speed passed; warning continues until maximum speed.
Attempted display 11	OFF after reset	OFF after reset	Depends after reset	Automatic limit reset clears invalid value.