

Project V07 Updated Truth Tables with 4-Bit Comparator

Assumed completed 74LS90 + 7447 cruise-speed-control system, now including a 74LS85 4-bit comparator section

This version updates Project V07 by adding the 4-bit comparator truth tables and connection logic. The original circuit is still the two-display 74LS90 + 7447 counter, but the completed design is assumed to include green/yellow range logic, XOR green correction, comparator warning, NE555 flashing red LED and automatic reset/limit logic.

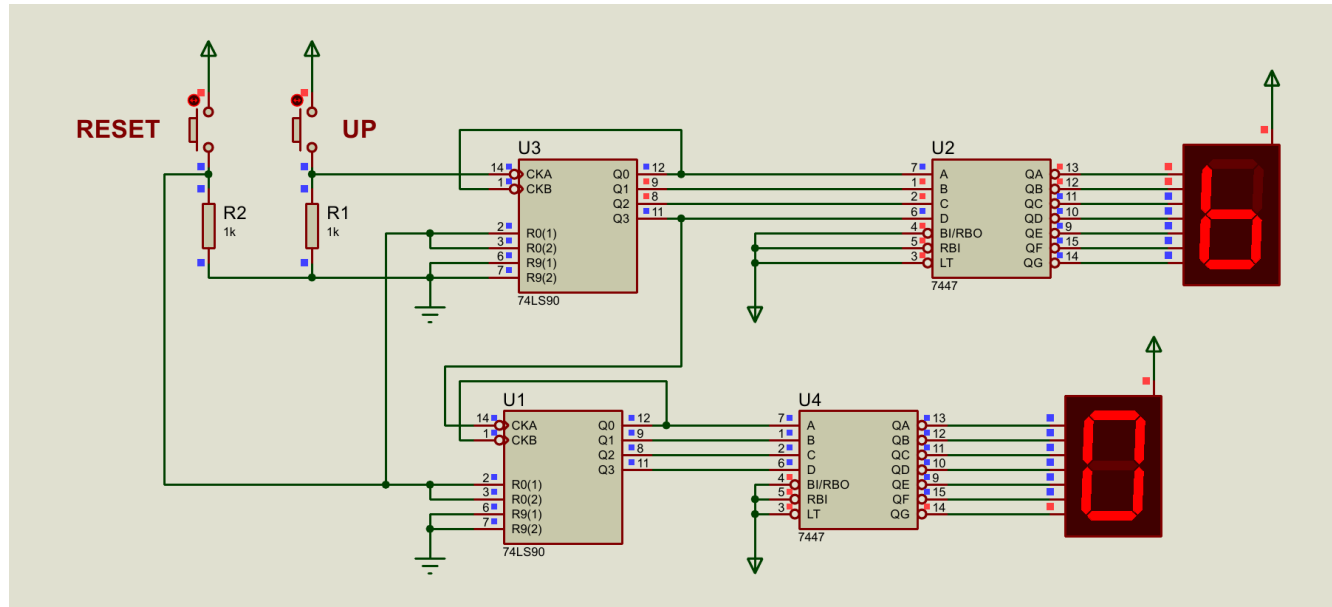


Figure 1: Original Project V07 counter/display circuit before completion.

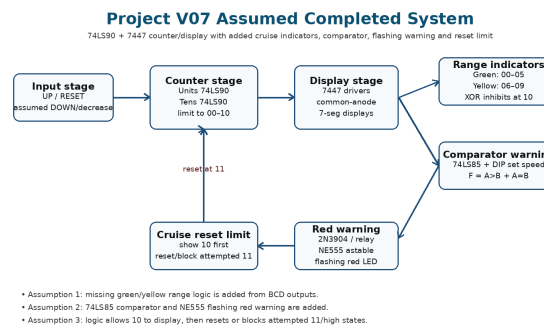


Figure 2: Assumed completed additions, including the 4-bit comparator warning path, range LEDs, NE555 flashing red warning and reset/limit logic.

1. Completed Circuit Assumptions

Assumed section	Function added to the original circuit
Green range logic	Turns green ON for speeds 00 to 05.
Yellow/amber range logic	Turns yellow ON for speeds 06 to 09.
XOR/inhibit correction	Uses A2/tens signal so green is OFF at speed 10.
4-bit comparator	Uses a 74LS85 to compare current speed with selected set speed.
Comparator red enable	RedEnable = $QA > B + QA = B$, with A2 also ORed if 10 is handled by max override.
NE555 flashing stage	Flashes red LED when RedEnable is HIGH.
Automatic 11 reset	Detects attempted 11 using A2 and unit A1 so the display does not remain above 10.

2. Updated Main Component Function Table

Component / label	Part	Function in completed Project V07
U1 and U3	74LS90	Unit and tens decade counters for the two-display count.
U2 and U4	7447 / 74LS47	BCD-to-seven-segment drivers for common-anode displays.
Added 74LS85	4-bit comparator	Compares current speed with selected cruise set speed.
Added DIP switch	4-bit set-speed input	Provides B3 B2 B1 B0 reference to the comparator.
Added OR gate	Comparator output combiner	Combines $QA > B$ and $QA = B$ to form F.
Added A2 override	Tens/max signal	Enables red flashing at maximum speed 10 if 10 is not directly encoded as 1010.
Added NE555 stage	Timer + driver	Flashes red LED when comparator warning is active.
Added reset/limit gate	AND/reset logic	Allows 10 to display and resets/blocks attempted 11.

3. 4-Bit Comparator Connection Table

The 74LS85 is used as a 4-bit magnitude comparator. For a single 4-bit comparator, the cascade inputs are set to $I(A>B)=0$, $I(A=B)=1$ and $I(A<B)=0$.

74LS85 pin group	Connection in completed Project V07
A3 A2 A1 A0	Current-speed 4-bit value from the counter/display logic. For 0-9 use unit BCD D C B A. For 10 use A2 max override or encoded 1010 logic.
B3 B2 B1 B0	Selected set-speed 4-bit reference from DIP switch.
$I(A>B)$	Tie LOW for single-comparator operation.
$I(A=B)$	Tie HIGH for single-comparator operation.
$I(A<B)$	Tie LOW for single-comparator operation.
$QA>B$	HIGH when current speed is greater than set speed.
$QA=B$	HIGH when current speed equals set speed.
$QA<B$	HIGH when current speed is lower than set speed.
RedEnable	$RedEnable = QA>B + QA=B + A2(max)$. If direct 0-10 encoding is used, A2 max override may be omitted.

4. 74LS85 4-Bit Comparator Truth Table

A represents the current-speed input and B represents the selected cruise-speed input.

$I(A>B)$	$I(A=B)$	$I(A<B)$	A vs B condition	$QA>B$	$QA=B$	$QA<B$	$F = QA>B + QA=B$	Red LED
0	1	0	$A < B$	0	0	1	0	OFF
0	1	0	$A = B$	0	1	0	1	Flashing
0	1	0	$A > B$	1	0	0	1	Flashing

5. Current-Speed Input Code for the 4-Bit Comparator

For speeds 0 to 9, the unit BCD code can be compared directly. At speed 10, Project V07 needs either an A2 maximum-speed override or extra encoding logic that converts 10 to binary/BCD 1010.

Displayed speed	Tens A2	Unit DCBA	74LS85 A3 A2 A1 A0 used	Max override	Meaning
00	0	0000	0000	0	Normal 4-bit compare using unit BCD
01	0	0001	0001	0	Normal 4-bit compare using unit BCD
02	0	0010	0010	0	Normal 4-bit compare using unit BCD
03	0	0011	0011	0	Normal 4-bit compare using unit BCD
04	0	0100	0100	0	Normal 4-bit compare using unit BCD
05	0	0101	0101	0	Normal 4-bit compare using unit BCD
06	0	0110	0110	0	Normal 4-bit compare using unit BCD
07	0	0111	0111	0	Normal 4-bit compare using unit BCD
08	0	1000	1000	0	Normal 4-bit compare using unit BCD
09	0	1001	1001	0	Normal 4-bit compare using unit BCD
10	1	0000 + A2	Unit 0000, A2 OR to RedEnable	1	Maximum-speed red enable comes from A2

6. Optional Direct 4-Bit Encoding Table for 0 to 10

This table is used only if the circuit is completed with extra encoding logic so that speed 10 is sent to the comparator as 1010. Without this extra encoding, use the A2 maximum-speed override method.

Speed	4-bit value	A3	A2	A1	A0	Use
0	0000	0	0	0	0	Direct 4-bit comparator code
1	0001	0	0	0	1	Direct 4-bit comparator code
2	0010	0	0	1	0	Direct 4-bit comparator code
3	0011	0	0	1	1	Direct 4-bit comparator code
4	0100	0	1	0	0	Direct 4-bit comparator code
5	0101	0	1	0	1	Direct 4-bit comparator code
6	0110	0	1	1	0	Direct 4-bit comparator code
7	0111	0	1	1	1	Direct 4-bit comparator code
8	1000	1	0	0	0	Direct 4-bit comparator code
9	1001	1	0	0	1	Direct 4-bit comparator code
10	1010	1	0	1	0	Direct 4-bit comparator code

7. Set-Speed DIP Switch Table

Set speed	DIP B3 B2 B1 B0	Meaning
6	0110	Red flashes when current speed $\geq$ 6
7	0111	Red flashes when current speed $\geq$ 7
8	1000	Red flashes when current speed $\geq$ 8
9	1001	Red flashes when current speed $\geq$ 9
10	1010	Red flashes when current speed $\geq$ 10

8. Comparator Matrix for Speeds 00 to 10

A value of 1 means the red warning condition is active for that selected set speed.

Current speed	Set 6	Set 7	Set 8	Set 9	Set 10	Red LED summary
0	0	0	0	0	0	OFF for set speeds 6-10
1	0	0	0	0	0	OFF for set speeds 6-10
2	0	0	0	0	0	OFF for set speeds 6-10
3	0	0	0	0	0	OFF for set speeds 6-10
4	0	0	0	0	0	OFF for set speeds 6-10
5	0	0	0	0	0	OFF for set speeds 6-10
6	1	0	0	0	0	Flashing for set speeds $\leq$ 6
7	1	1	0	0	0	Flashing for set speeds $\leq$ 7
8	1	1	1	0	0	Flashing for set speeds $\leq$ 8
9	1	1	1	1	0	Flashing for set speeds $\leq$ 9
10	1	1	1	1	1	Flashing for set speeds 6-10

9. 74LS90 BCD Counter Truth Table

Decimal	Q3/D	Q2/C	Q1/B	Q0/A	BCD DCBA	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

10. 7447 Common-Anode Display Truth Table

For the 7447 / 74LS47 common-anode driver, 0 means segment ON and 1 means segment OFF.

Digit	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

11. Updated 00 to 10 Operating Truth Table

Speed	Tens BCD	Units BCD	Tens display	Units display	Green	Yellow	Red warning	State
00	0000	0000	0	0	1	0	Depends on 4-bit comparator	0-5 green range
01	0000	0001	0	1	1	0	Depends on 4-bit comparator	0-5 green range
02	0000	0010	0	2	1	0	Depends on 4-bit comparator	0-5 green range
03	0000	0011	0	3	1	0	Depends on 4-bit comparator	0-5 green range
04	0000	0100	0	4	1	0	Depends on 4-bit comparator	0-5 green range
05	0000	0101	0	5	1	0	Depends on 4-bit comparator	0-5 green range
06	0000	0110	0	6	0	1	Depends on 4-bit comparator	6-9 yellow range
07	0000	0111	0	7	0	1	Depends on 4-bit comparator	6-9 yellow range
08	0000	1000	0	8	0	1	Depends on 4-bit comparator	6-9 yellow range

Speed	Tens BCD	Units BCD	Tens display	Units display	Green	Yellow	Red warning	State
09	0000	1001	0	9	0	1	Depends on 4-bit comparator	6-9 yellow range
10	0001	0000	1	0	0	0	Flashing by A2/max or encoded compare	Maximum speed displayed

12. Green / Yellow LED Logic with Comparator System

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

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

Final Green = Green base XOR A2

RedEnable = QA>B + QA=B + A2(max override)

Speed	Unit DCBA	A2/Tens	Yellow	Green base	Final green	Indicator result
00	0000	0	0	1	1	Green ON
01	0001	0	0	1	1	Green ON
02	0010	0	0	1	1	Green ON
03	0011	0	0	1	1	Green ON
04	0100	0	0	1	1	Green ON
05	0101	0	0	1	1	Green ON
06	0110	0	1	0	0	Yellow ON
07	0111	0	1	0	0	Yellow ON
08	1000	0	1	0	0	Yellow ON
09	1001	0	1	0	0	Yellow ON
10	0000	1	0	1	0	Green/yellow OFF

13. Automatic Reset / Maximum-Speed Limit Truth Table

Present display	UP pulse	Tens A2	Unit A1	Reset11 = A2.A1	Action
00 to 08	1	0	0/1	0	Counts normally upward.
09	1	0	1	0	Moves to 10 on next valid transition.
10	1	1	0	0	Maximum speed remains visible.
11 attempted	X	1	1	1	Automatic reset/limit clears or blocks invalid state.
Any value	Manual RESET = 1	X	X	X	Display returns to 00 for start-up/testing.

14. NE555 Flashing Red LED Truth Table

RedEnable	Transistor/relay stage	NE555 state	Red LED state
0	OFF	Disabled or reset held	OFF
1	ON	Astable flashing mode	Flashing

15. Final Updated Operating Summary

Condition	4-bit comparator	Green LED	Yellow LED	Red LED	Display behaviour
Speed 00 to 05	A compared with B	ON	OFF	Depends on comparator	Low speed range.
Speed 06 to 09	A compared with B	OFF	ON	Depends on comparator	Higher speed range.
Current speed < set speed	QA<B=1	Range LED works	Range LED works	OFF	Cruise speed not reached.
Current speed = set speed	QA=B=1	Range LED works	Range LED works	Flashing	Cruise speed reached.
Current speed > set speed	QA>B=1	Range LED works	Range LED works	Flashing	Cruise speed passed.
Speed 10	A2 override or encoded 1010	OFF	OFF	Flashing if set/max active	Maximum speed displayed.
Attempted 11	Reset11=1	OFF after reset	OFF after reset	Reset/controlled	Automatic cruise reset clears invalid state.