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CONTROL SYSTEMS 3 (CSS370S)

FINAL PROJECT PART 1: GA1 EVALUATION

PROJECT V02: 74LS192 / 74LS48 TWO-DISPLAY CRUISE SPEED CONTROL SYSTEM

System Design and Development, Simulation, Truth Tables and Practical Implementation Discussion

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Declaration

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Summary/Abstract

This report presents Project V02 of the CSS370S GA1 cruise speed control simulation. The project brief requires a practical electronic solution with no microcontroller and no PLC. The design must show the current simulated speed, indicate the lower speed range from 0 to 5 using a green LED, indicate the 6 to 9 range using a yellow/amber LED, flash a red LED when the selected cruise speed is reached, display a maximum speed of 10, and provide an automatic cruise reset or limit action that is separate from an ordinary manual reset button.

Project V02 uses two 74LS192 BCD up/down decade counters, two 74LS48 BCD-to-seven-segment display drivers, common-cathode seven-segment displays, a 74LS85 comparator, logic gates, a 2N3904 transistor/relay interface, and an NE555 astable flashing circuit. The unit counter displays 0 to 9 while the tens counter allows the maximum value 10 to be shown. Additional XOR and reset logic is included to force the green LED OFF at 10 and to prevent the counter from continuing into invalid states such as 11 and 99.

The solution was analysed stage by stage using component function tables, counter truth tables, display truth tables, range indicator truth tables, comparator tables, and red flashing LED operation tables. The results show that the proposed electronic design satisfies the main functional requirements of the project, with the main limitation being that the speed value is simulated through digital counting rather than being measured from a physical vehicle-speed sensor.

Table of Contents

Table of Figures (TOF)

Table of Tables (TOT)

Table of Acronyms

Acronym	Meaning
BCD	Binary Coded Decimal
CC	Common Cathode

LED	Light Emitting Diode
LSB	Least Significant Bit
MSB	Most Significant Bit
TTL	Transistor-Transistor Logic
VCC	Positive supply voltage
GND	Ground reference
GA1	Graduate Attribute 1: Problem Solving

1. Introduction

The CSS370S GA1 project requires students to develop and demonstrate a practical cruise speed control simulation using electronic circuits. The project is performed to test problem-solving ability, stage-by-stage design development, and the implementation of a broadly defined engineering problem using practical electronic components rather than a microcontroller or PLC.

The aim of Project V02 is to design and document a two-display cruise speed control circuit that can count the current simulated speed from 00 to 10, show the 0 to 5 range with a green LED, show the 6 to 9 range with a yellow/amber LED, and flash a red LED when the selected cruise speed is reached or exceeded. The selected speed is applied through a DIP switch and compared with the current speed using a magnitude comparator.

The problem addressed by this design is how to produce a complete control indication system using only counters, decoders, logic gates, comparator circuitry, and a timer stage. The design must also avoid an invalid continued count after the maximum speed. Therefore, Project V02 includes automatic reset/limit logic to allow 10 to be displayed while preventing invalid states after 10.

The main objectives were achieved in simulation: the two seven-segment displays show the speed range, the green and yellow LEDs follow the required range conditions, and the red LED flashes according to the comparator output. The project also demonstrates that logic gates can be used to correct indicator behaviour at the maximum speed state.

2. System description

The Project V02 system is built around a two-counter digital speed display. The first 74LS192 counter controls the unit display and the second 74LS192 counter controls the tens display. The BCD outputs are decoded by 74LS48 drivers and shown on common-cathode seven-segment displays. The comparator stage uses the present count and the selected DIP switch setting to decide whether the current speed has reached the selected cruise speed.

Figure 1 presents the complete Project V02 circuit used for the report. The figure shows the two 74LS192 counters, two 74LS48 display drivers, the 74LS85 comparator, the green/yellow logic gates, the transistor/relay interface, and the NE555 flashing red LED section.

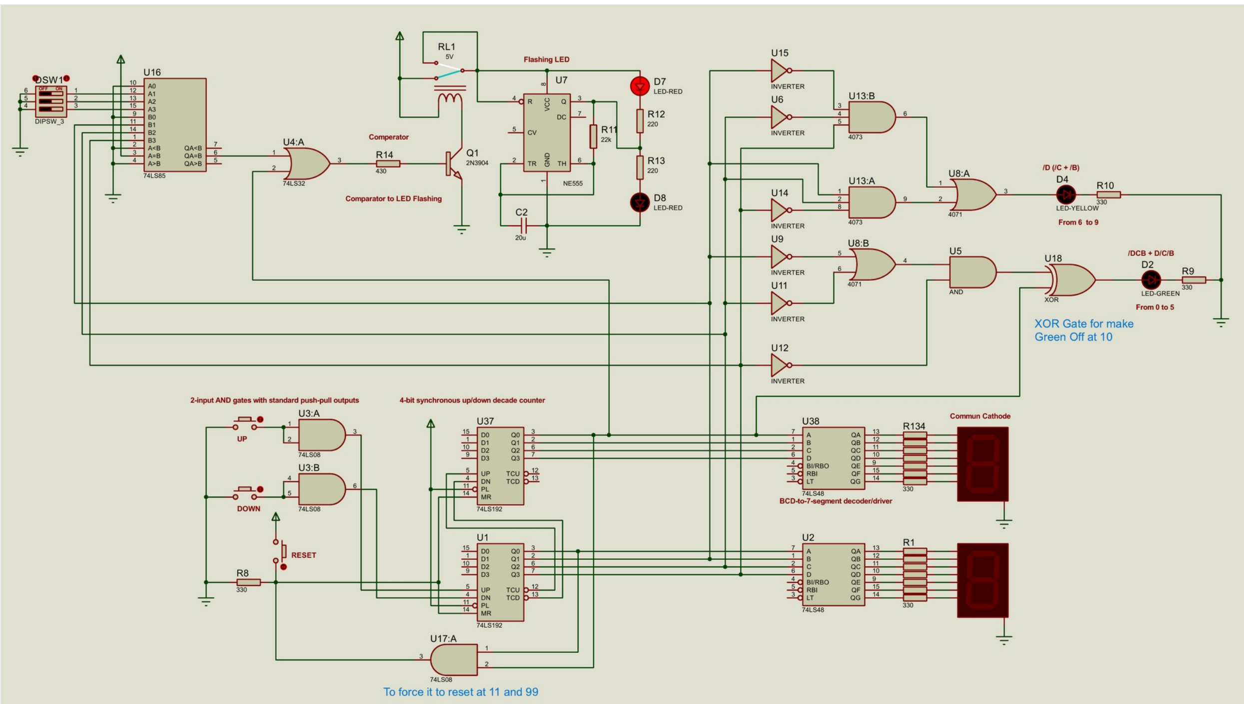

Figure 1: Project V02 74LS192 / 74LS48 cruise speed control circuit

The updated design also includes two important correction sections. The first correction uses an XOR gate so that the green LED does not remain active when the display reaches 10. The second correction uses reset/limit logic so that an attempted invalid count beyond 10 is cleared or blocked. Figure 2 presents the additional reset and XOR correction details used in the updated truth-table analysis.

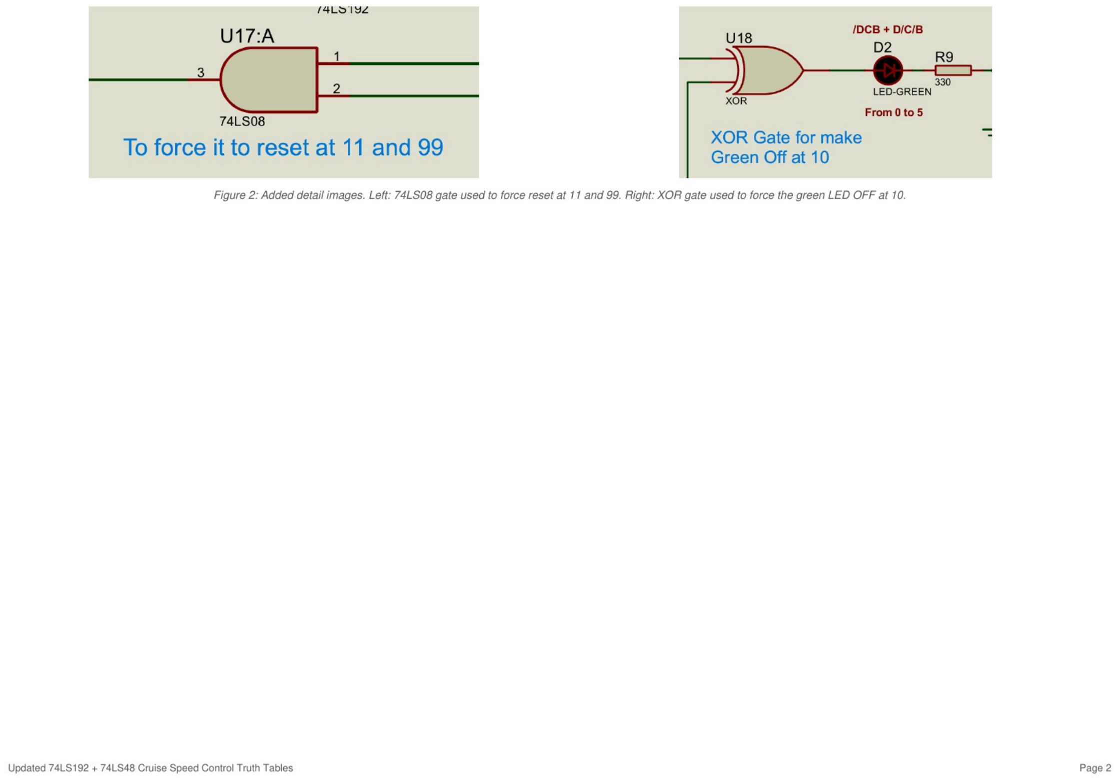

Figure 2: Added reset and XOR correction details used in Project V02

Table 1 summarises the required operating conditions that were used to evaluate the Project V02 circuit.

Table 1: Required operating conditions for the cruise speed control system

Condition	Required output
Speed 00 to 05	Green LED ON, yellow LED OFF. Red LED depends on comparator set speed.
Speed 06 to 09	Yellow/amber LED ON, green LED OFF. Red LED depends on comparator set speed.
Selected cruise speed reached	Comparator output becomes HIGH and the red LED flashes through the NE555 stage.
Speed 10	Maximum speed must be displayed. Green and yellow indicators are OFF.
Attempted count beyond 10	Automatic reset or limit logic must prevent continued invalid counting.

Table 2 identifies the main components and the role of each component group in the Project V02 solution.

Table 2: Main component function table for Project V02

Component / label	Part	Function in this solution
U1 and U37	74LS192	Unit and tens BCD up/down decade counters.
U2 and U38	74LS48	BCD-to-seven-segment drivers for common-cathode displays.
U3:A, U3:B	74LS08	Condition the UP and DOWN push-button pulses.
U16	74LS85	Compares the current speed value with the DIP-switch set speed.
DSW1	DIP switch	Provides the selected cruise speed to the comparator.
U13:A, U13:B, U8:A	4073 and 4071	Create yellow/amber detection for the 06 to 09 range.
U5 and U18	AND and XOR gates	Create corrected green output and force green OFF at 10.
U17:A	74LS08	Supports reset/limit detection at invalid states such as 11 and high-state protection.
Q1, RL1, U7	2N3904, relay, NE555	Enable and flash the red LED warning when the comparator output is HIGH.

Table 3 describes the signal flow from the user inputs to the final visual indicators. This makes the design easier to understand as separate working stages before discussing the detailed truth tables.

Table 3: System signal flow table

Stage	Signal path	Meaning
Counting and display	UP/DOWN/RESET -> 74LS192 counters -> 74LS48 drivers -> seven-segment displays	Shows the current simulated speed from 00 to 10.
Range indication	Unit BCD outputs and tens correction signal -> logic gates -> green/yellow LEDs	Separates the 00-05 range from the 06-09 range and switches both range LEDs OFF at 10.
Comparator decision	Current speed lines and DIP switch set-speed lines -> 74LS85	Checks whether the current speed has reached or passed the selected cruise value.
Red warning	Comparator output -> transistor/relay -> NE555 -> red LED	Flashes the red LED when the warning condition is active.
Limit/reset logic	Invalid state detection -> reset/limit path	Allows 10 to be displayed and prevents continued invalid counting.

2.1 Stage 1: Development and overall approach to solution of automated system

The overall solution was developed as a staged electronic system. The first stage was the counter/display block, because the current speed must be visible before the range indicators and comparator can be verified. Two 74LS192 counters were selected because they provide BCD up/down counting and can be cascaded for two-digit display operation [1].

The display stage uses 74LS48 decoder/drivers with common-cathode displays. The 74LS48 converts the BCD output from each counter into seven-segment display signals, which allows the unit and tens values to be observed directly [2]. Once the count display was stable, the green/yellow range logic, comparator stage, red flashing circuit, and reset correction logic were added.

2.2 Stage 2: Development and solution of the analog detection/sensors stage

Project V02 is a digital simulation of the cruise speed control concept rather than a physical vehicle-speed measurement circuit. The speed input is therefore simulated using UP and DOWN push buttons connected to the counter stage. This allows the speed value to be increased or decreased during testing while still respecting the project requirement that the solution must use electronic circuits only.

In a complete physical implementation, this stage could be replaced by an analog detector and signal-conditioning circuit that generates a speed-related voltage. For Project V02, the counter stage represents the current-speed signal used by the display, range indication, and comparator sections. This interpretation allows the practical simulation to focus on the logic and control response of the cruise-speed system.

2.3 Stage 3: Development and solution of determination of increasing/decreasing speed

The increasing and decreasing speed behaviour is created using the UP and DOWN inputs of the 74LS192 counters. A pulse on the UP input increases the displayed value, while a pulse on the DOWN input decreases the displayed value. The unit counter handles values from 0 to 9, and the tens counter allows the maximum value of 10 to be shown.

The logic must also prevent invalid operation when the count moves beyond the required project maximum. For this reason, the design includes correction logic that detects an attempted invalid state after 10. The additional reset/limit circuit is not the same as the manual reset button; it is part of the automatic cruise reset requirement and is used to keep the system inside the valid range.

2.4 Stage 4: Development and solution of relevant alarms/indicators/displays of the system

The relevant indication stage consists of the two seven-segment displays, green LED, yellow/amber LED, and red flashing LED. The display output shows the current simulated speed. The green LED is active for 00 to 05, the yellow LED is active for 06 to 09, and both range LEDs are inactive at 10. The XOR correction is necessary because simple inverted-yellow logic can otherwise switch green back ON at a two-digit maximum state.

The red flashing LED is controlled separately from the green/yellow range indication. The 74LS85 comparator provides the warning decision by comparing the current speed with the selected set speed [3]. When the current speed is equal to or greater than the set speed, the comparator output enables the transistor/relay path and the NE555 astable flashing circuit [4]. The 2N3904 transistor is used as a switching device for the relay/enable stage [5].

2.5 Stage 5: Overall approach to system design and solution development

After the individual sections were developed, the final stage was to combine the counting, display, LED range, comparator, red warning, and reset/limit circuits. The design was then checked using truth tables to confirm that each input condition produces the expected output. The truth tables are important because they show the logic decision for every valid displayed speed from 00 to 10.

The project demonstrates a practical electronics approach to the cruise-speed problem. Instead of using software logic, the design uses counters, decoders, comparators, gates, and a timer circuit to produce the required system response.

3. Observations and results

The main observations and results are presented through the truth tables. Table 4 confirms the BCD count sequence for one 74LS192 counter, while Table 5 confirms the seven-segment output pattern used by the 74LS48 display driver.

Table 4: 74LS192 BCD counter truth table for one digit

Decimal digit	D	C	B	A	BCD D C B A
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

Table 5 gives the common-cathode segment outputs for the 74LS48 driver. In this table, logic 1 switches a segment ON and logic 0 switches it OFF.

Table 5: 74LS48 common-cathode seven-segment truth table

Decimal	BCD	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

Table 6 shows the complete valid two-display sequence for the required operating range. The design reaches 10 as the maximum speed and uses reset/limit logic to stop the system from continuing into invalid display states.

Table 6: Two-display speed sequence from 00 to 10

Speed	Tens BCD	Units BCD	Tens display	Units display	State meaning
00	0000	0000	0	0	Green range
01	0000	0001	0	1	Green range
02	0000	0010	0	2	Green range
03	0000	0011	0	3	Green range
04	0000	0100	0	4	Green range
05	0000	0101	0	5	Green range
06	0000	0110	0	6	Yellow/amber range
07	0000	0111	0	7	Yellow/amber range
08	0000	1000	0	8	Yellow/amber range
09	0000	1001	0	9	Yellow/amber range
10	0001	0000	1	0	Maximum speed displayed

Table 7 verifies the green/yellow logic after the XOR correction is applied. The result confirms that green is active only from 00 to 05, yellow is active from 06 to 09, and both range LEDs are OFF at 10.

Table 7: Green/yellow LED range truth table with XOR correction

Speed	T	D	C	B	A	Green	Yellow	Result
00	0	0	0	0	0	1	0	Green ON
01	0	0	0	0	1	1	0	Green ON
02	0	0	0	1	0	1	0	Green ON
03	0	0	0	1	1	1	0	Green ON
04	0	0	1	0	0	1	0	Green ON
05	0	0	1	0	1	1	0	Green ON
06	0	0	1	1	0	0	1	Yellow ON
07	0	0	1	1	1	0	1	Yellow ON
08	0	1	0	0	0	0	1	Yellow ON
09	0	1	0	0	1	0	1	Yellow ON
10	1	0	0	0	0	0	0	Both OFF

Table 8 shows the automatic reset and limit operation. The manual reset can clear the display at any time, but the automatic limit reset is used specifically to prevent invalid states after the maximum speed.

Table 8: Automatic reset and limit truth table

Present display	UP pulse	Reset at 11	Reset at 99	Action
00 to 08	1	0	0	Counts normally upward.
09	1	0	0	Advances to 10.
10	1	1	0	Attempted 11 is reset or blocked.
11 attempted	X	1	0	Invalid state is cleared.
99 attempted / high state	X	X	1	Tens reset protection becomes active.
Any value	Manual reset = 1	X	X	Display returns to 00.

Table 9 confirms the comparator decision used to enable the red flashing warning. The comparator output F becomes HIGH when the current speed is equal to or greater than the selected set speed.

Table 9: 74LS85 comparator output truth table

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

Table 10 gives the NE555 flashing-stage truth table. When F is LOW, the red LED remains OFF. When F is HIGH, the timer operates in astable mode and the red LED flashes.

Table 10: NE555 flashing red LED operation 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

Table 11 summarises the complete observed operation of Project V02 after combining the counter, range indication, comparator, red flashing, and reset/limit stages.

Table 11: Observed operating summary

Condition	Green LED	Yellow LED	Red flashing LED	Display behaviour
Speed 00 to 05	ON	OFF	Depends on comparator set speed	Normal lower-speed range.
Speed 06 to 09	OFF	ON	Depends on comparator set speed	Amber/yellow range.
Speed 10	OFF	OFF	Flashing if selected speed has been reached	Maximum speed displayed.
Attempted 11	OFF after reset	OFF after reset	Depends after reset	Automatic reset/limit clears invalid state.
Attempted 99/high state	OFF after reset	OFF after reset	Depends after reset	Tens reset protection prevents unwanted high counts.

4. Conclusion

Project V02 successfully demonstrates a two-display cruise speed control simulation using electronic components only. The circuit uses two 74LS192 counters and two 74LS48 display drivers to show the current speed from 00 to 10. The green/yellow LED logic satisfies the required speed ranges, and the added XOR correction ensures that the green LED is OFF at the maximum speed state. The comparator and NE555 stage provide the flashing red warning when the current speed reaches or exceeds the selected cruise speed.

The automatic reset/limit logic addresses the project requirement that the cruise reset must not be treated only as a normal reset button. The circuit allows the maximum speed of 10 to be displayed, then prevents invalid counting beyond the valid range. The main limitation is that Project V02 simulates the speed input using push buttons and counters; a future version could connect a physical analog detector and signal-conditioning stage to generate the speed signal automatically.

Bibliography

[1] Texas Instruments, "SN54192, SN54LS192, SN74192, SN74LS192 Synchronous 4-Bit Up/Down Decade Counters," data sheet, available from Texas Instruments.

[2] Texas Instruments, "BCD-to-Seven-Segment Decoders/Drivers," data sheet for the SN54/74LS47 and related devices, available from Texas Instruments.

[3] Texas Instruments, "SN74LS85 4-Bit Magnitude Comparators," data sheet, available from Texas Instruments.

[4] Texas Instruments, "NE555 Precision Timers," data sheet, available from Texas Instruments.

[5] onsemi, "2N3904 NPN General-Purpose Amplifier," data sheet, available from onsemi.

[6] Cape Peninsula University of Technology, "CSS370S GA1 Project 2026 Brief," Department of Electrical, Electronic and Computer Engineering, 2026.

Appendices

APPENDIX A: Project V02 truth-table pack

Appendix A refers to the separate Project V02 truth-table PDF supplied with this report. The truth-table pack includes the circuit interpretation, component function table, BCD counter table, display table, green/yellow range table, reset table, comparator table, and NE555 flashing red LED table. The most important tables are reproduced in the Observations and results section of this report to support the main discussion.

APPENDIX B: Project V02 schematic

Appendix B refers to the Project V02 Proteus schematic used as the circuit source. The schematic shows the 74LS192 counter stage, 74LS48 display stage, 74LS85 comparator stage, NE555 flashing stage, and the additional XOR/reset correction logic.

APPENDIX C: Practical and report evaluation schemes

The practical and report evaluation schemes are retained as part of the original CSS370S GA1 template. They support the GA1 problem-solving assessment by linking the report to problem definition, strategy formulation, solution analysis, and implementation.