Faculty of Engineering and Built Environment Cape Peninsula University of Technology

Department of Electrical, Electronic and Computer Engineering (DEECE)
Bachelor of Engineering Technology: Electrical Engineering

CONTROL SYSTEMS 3 (CSS370S)

FINAL PROJECT PART 1: GA1 EVALUATION

SYSTEM DESIGN & DEVELOPMENT, CLOSED LOOP CONTROL SYSTEM DESIGN, SIMULATION & PRACTICAL IMPLEMENTATION

PROJECT V01 - ONE COUNTER CRUISE SYSTEM

Circuit focus: counter/display stage, 74LS85 comparator, gate logic and NE555 flashing warning

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Date: 19 June 2026

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Declaration

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Summary/Abstract

This report presents the design and simulation of Project V01, a one-counter cruise-speed control demonstration for Control Systems 3. The project required a practical electronic solution without microcontroller or PLC control. The solution therefore uses counter/display circuitry, BCD logic, a 74LS85 magnitude comparator, range-detection gates and an NE555 astable timer to show the current speed, compare it with a selected cruise reference and produce the required indicator outputs.

The system displays the vehicle speed from 00 up to the required maximum of 10. Speeds 00 to 05 are indicated by the green output, speeds 06 to 09 are indicated by the amber/yellow output, and the red indicator flashes when the selected cruise speed is reached or exceeded. The design was developed stage by stage so that the counter, display, comparator, range logic and flashing-warning sections could be verified individually before being combined into the complete simulated control system.

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Table of Acronyms

Table 4: Table of acronyms

Acronym	Meaning
BCD	Binary Coded Decimal
CLK	Clock input
DIP	Dual in-line package switch
LED	Light Emitting Diode
LSB	Least Significant Bit
NE555	555 timer integrated circuit used as an astable flasher
PLC	Programmable Logic Controller
VCC	Positive supply voltage

1. Introduction

The project was performed to demonstrate stage-wise design, implementation and evaluation of an electronic control-system solution. The required application is a simulated vehicle cruise-speed control system that displays the current speed, compares it with a set-speed reference and activates the correct visual warning state.
The aim of the project was to design a practical electronic circuit that demonstrates the cruise-speed control function without using a microcontroller or PLC. The design had to provide a current-speed display, a selected cruise-speed input, a green indication for speeds 0 to 5, an amber/yellow indication for speeds 6 to 9, a flashing red indication when the cruise value is reached and a visible maximum speed of 10.

The problem addressed by the project is the conversion of a changing speed value into meaningful digital outputs using only electronic components. The system must count the speed, display the speed, compare the current speed to a set point and prevent confusion when the maximum value is reached. This is a broadly defined engineering problem because it requires digital counting, comparison, logic decision-making, display decoding and warning generation to work together.

The project is relevant to Control Systems 3 because it shows how a practical control objective can be divided into functional stages. Each stage can be tested independently before being connected to the next stage. This reduces fault-finding difficulty and improves the reliability of the final circuit.

The objectives were achieved in simulation. The circuit produces the required green, yellow and flashing red outputs, displays the maximum speed of 10 and uses a logic-based reset/maximum-speed control path rather than relying only on a manual reset button. The main lesson from the work is that the final solution becomes easier to explain and improve when the design is built from smaller verified blocks.

2. System description

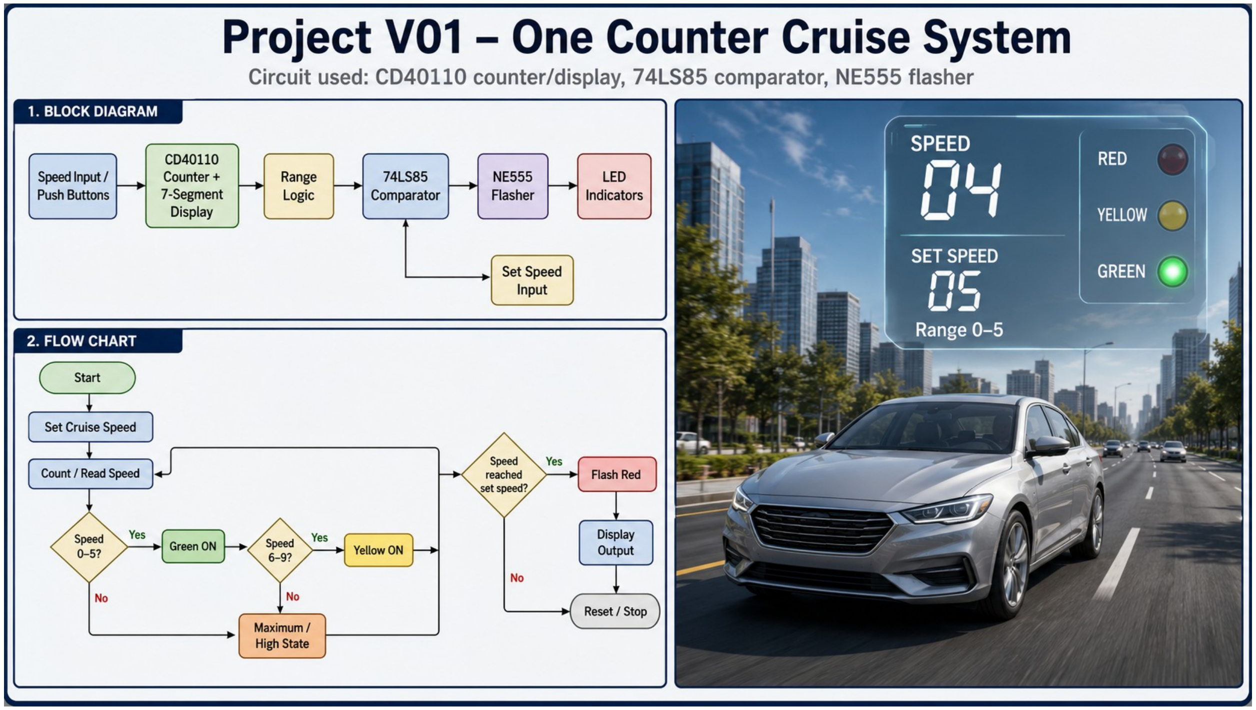

Figure 1: Project V01 automated cruise-speed control system overview.

Figure 1 introduces the complete Project V01 concept. The left side summarises the block diagram and the flow chart, while the right side shows how the simulated vehicle state is represented visually. The design is treated as an electronic implementation of a cruise-speed control display and warning system. The counter/display stage produces the current speed, the set-speed input provides the reference, the comparator checks whether the reference has been reached, and the indicator stage produces green, yellow or flashing red outputs.

Table 5 identifies the main hardware blocks used in the final solution. The counter and display section is responsible for representing the current speed, while the comparator and NE555 sections are responsible for the cruise warning state.

Table 5: Main component function table

Component / block	Circuit part	Purpose in the project
Speed input / push buttons	Manual electronic input stage	Represents increase, decrease and reset actions during simulation testing.
Counter/display function	CD40110 concept or CD4029 with CD4511 display drivers in the supplied schematic	Counts and displays the current speed as a seven-segment decimal value.
Range logic	AND, OR, NOT and XOR gates	Separates speeds 00-05, 06-09 and maximum-speed logic.
74LS85 comparator	4-bit magnitude comparator	Compares current speed with the selected cruise set-speed reference.
DIP switch set-speed input	Manual BCD reference input	Provides the cruise-speed value used by the comparator.
NE555 flasher	Astable timer circuit	Produces the flashing red warning signal.
LED indicators	Green, yellow and red outputs	Shows the operating condition of the simulated cruise system.

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

The complete cruise-speed system was first divided into functional blocks so that each block could be tested independently. The system starts with a speed input stage, then passes the current speed value to the counter/display stage, the range-logic stage and the comparator stage. The comparator output then enables the flashing red warning stage when the set-speed condition is reached.

Figure 2 shows the block-level design used to guide the practical implementation. This stage was important because it confirmed the signal flow before the detailed circuit was assembled.

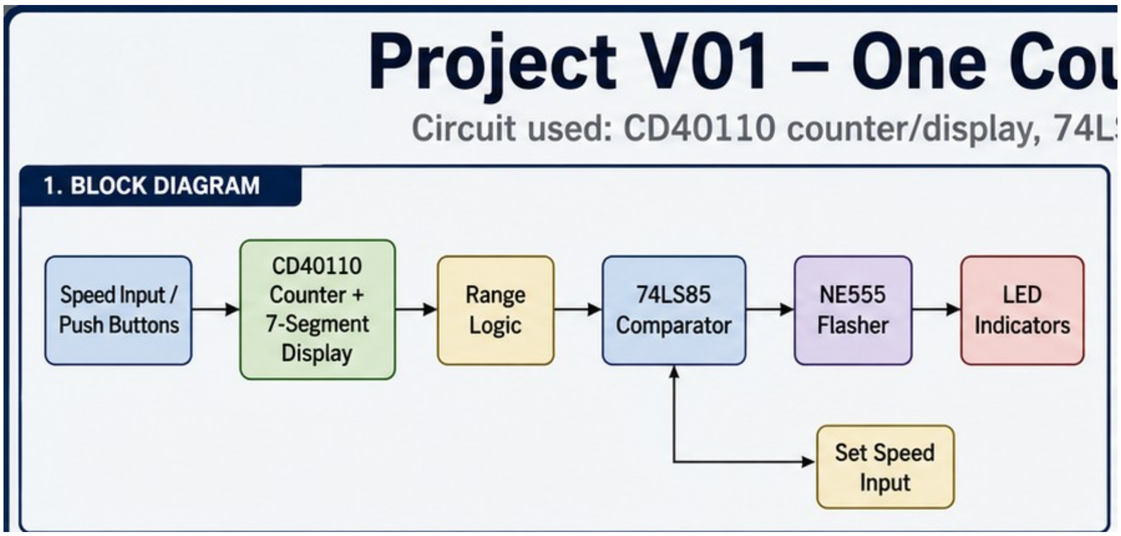

Figure 2: Functional block diagram of the one-counter cruise system.

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

In the supplied simulation, the analogue detector stage is represented by manual electronic speed inputs. The push buttons provide controlled test pulses for increasing, decreasing and resetting the displayed speed. This approach makes the logic easier to verify because every count can be checked directly on the seven-segment display.

For a physical extension of the project, the detector stage can be replaced by an analogue speed sensor and signal-conditioning circuit. The conditioned signal would need to be scaled to the detector range suggested in the brief and then converted into a count or comparison signal. In this report, the focus remains on the validated counter, comparator and indicator logic.

2.3. Stage 3: Development and solution of determination of increasing/decreasing speed (digital and analog solutions)

The increasing/decreasing speed stage is controlled by the UP and DOWN inputs. A pulse on the UP input increases the displayed speed by one count, while a pulse on the DOWN input decreases it by one count. The manual RESET input is included for initialisation and testing, but the cruise reset/maximum-speed action is treated separately as a logic-based function.

Table 6 summarises the input actions used to verify the counter behaviour in simulation. The invalid case occurs when UP and DOWN are activated together and should be avoided during normal operation.

Table 6: Input and counter control table

DOWN	UP	RESET	Clock	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	Reset	Manual clear	Display returns to 00

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

The alarm, indicator and display stage converts the counter output into visible information. The seven-segment display shows the current speed. The green indicator represents the 00 to 05 speed range, the yellow indicator represents the 06 to 09 range, and the red indicator flashes when the selected cruise speed is reached or exceeded. At speed 10, green and yellow are both OFF while the red warning remains active.

The range decision is implemented using BCD logic equations. In the equations, / means NOT, a dot means AND, and + means OR. A2 is the tens signal used to identify the maximum-speed condition.

(1) Base Green = /D . (/C + /B)

Equation 1: Base green range logic for speeds 00 to 05.

(2) Base Yellow = (/D . C . B) + (D . /C . /B)

Equation 2: Base yellow range logic for speeds 06 to 09.

(3) Final Green = Base Green XOR A2

Equation 3: Final green logic with maximum-speed correction.

Table 7: Display and indicator truth table for 00 to 10

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

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

After the individual stages were checked, the complete circuit was assembled in simulation. Figure 3 shows the final schematic used to verify the complete cruise-speed control solution. The schematic includes the counter/display section, the range logic, the 74LS85 comparator, the DIP-switch set-speed reference, the transistor/relay enable path and the NE555 red flasher.

The design approach followed a practical engineering sequence: define the required outputs, produce the counter and display first, add the range logic, add the comparator and finally connect the flashing warning stage. This reduced the risk of connecting a full circuit before the individual sections were understood.

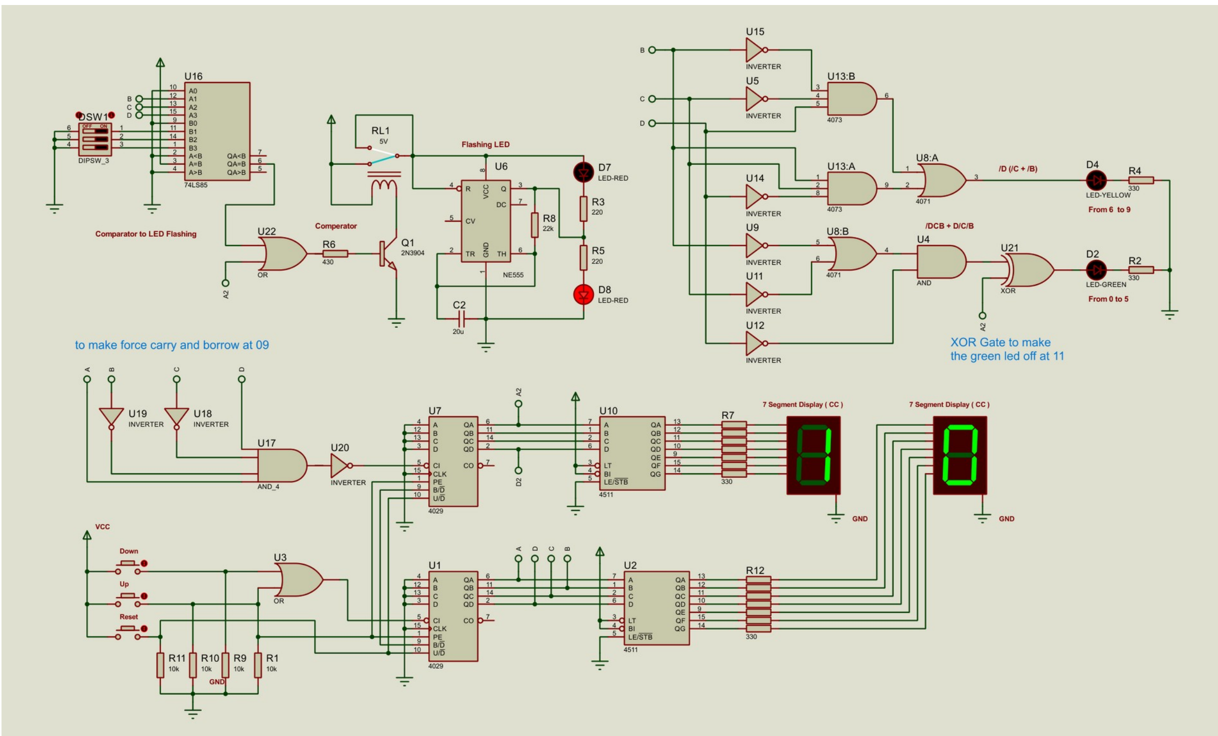

Figure 3: Simulated electronic schematic used for the project implementation.

3. Observations and results

The observed simulation behaviour matches the required control states. Figure 4 presents the logic flow used during testing. The circuit reads or counts the current speed, checks the range, compares the current speed with the selected cruise value and activates the required indicator output.

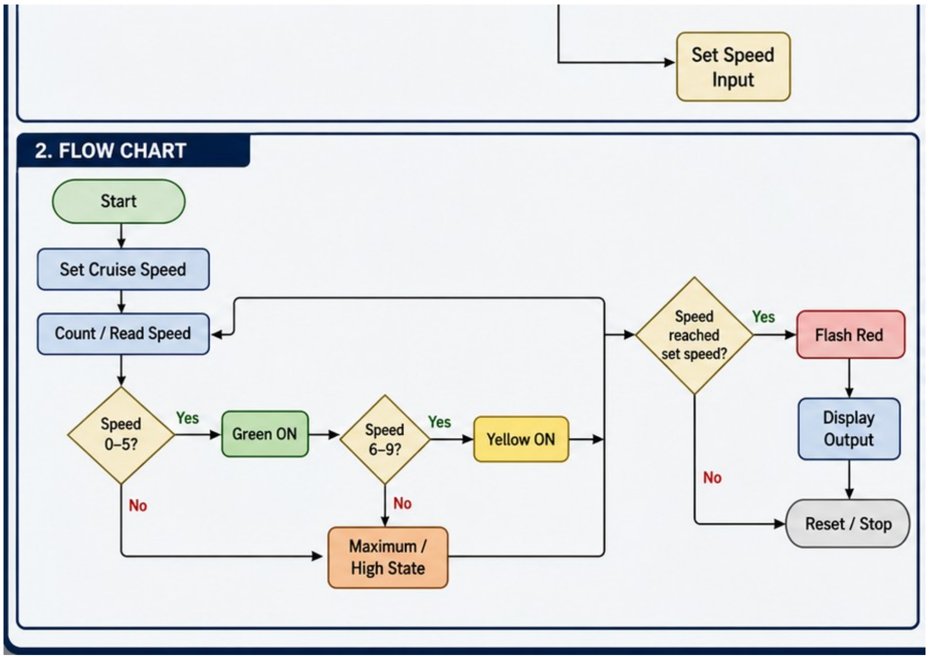

Figure 4: Flow chart for the cruise-speed decision sequence.

Table 8 verifies the comparator section. The 74LS85 output used for the warning is active when the current speed is equal to or greater than the selected set speed.

$$(4) \quad F = (A > B) + (A = B)$$

Equation 4: Comparator warning condition.

$$(5) \quad \text{Warning Enable} = F + A2$$

Equation 5: Red flashing warning enable condition.

Table 8: Comparator and red warning truth table

Current speed condition	A>B	A=B	A<B	F	A2	Warning enable	Red LED
Current speed < Set speed	0	0	1	0	0	0	OFF
Current speed = Set speed	0	1	0	1	0	1	Flashing
Current speed > Set speed	1	0	0	1	0	1	Flashing
Maximum speed 10 reached	X	X	X	X	1	1	Flashing

Table 9: Final operating summary

Condition	Green	Yellow	Flashing red	Display action
Speed 00 to 05	ON	OFF	Depends on comparator set speed	Displays 00 to 05
Speed 06 to 09	OFF	ON	Depends on comparator set	Displays 06 to 09

			speed	
Current speed < set speed	Range LED works	Range LED works	OFF	Displays current speed
Current speed = set speed	Range LED works	Range LED works	Flashing	Displays current speed
Current speed > set speed	Range LED works	Range LED works	Flashing	Displays current speed
Speed 10	OFF	OFF	Flashing	Displays maximum speed 10
Count above 10	OFF	OFF	Reset path active	Returns to 00

4. Conclusion

Project V01 was successfully developed as an electronic one-counter cruise-speed control demonstration. The project problem was solved by dividing the system into speed input, counter/display, range logic, comparator and flashing-warning stages. This made it possible to test the design stage by stage before combining the complete circuit.

The final simulated design meets the main requirements of the brief. It avoids microcontroller and PLC control, displays the current speed, shows green for speeds 00 to 05, shows yellow for speeds 06 to 09, flashes red when the cruise set speed is reached or exceeded, and displays the maximum speed of 10. The main limitation is that the speed detector is represented by manual pulses instead of a real analogue sensor. A future improvement would be to add a physical sensor and conditioning circuit before the counter/display stage.

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[3] New Project electronic schematic supplied for the cruise-speed control circuit, 2026.
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Glossary of Terms

Table 10: Glossary of terms

Term	Explanation
Cruise speed	The selected reference speed used by the comparator.
Current speed	The speed value shown on the seven-segment display.
Comparator	A circuit that checks whether one binary value is less than, equal to or greater than another.
Astable timer	A timer circuit that continuously changes output state to create a flashing signal.
Maximum speed	The highest visible speed required by the project, equal to 10.

Appendices

APPENDIX A: Practical evaluation scheme

A. PRACTICAL EVALUATION:	**MARK WEIGHT**	**OBTAINED MARK**
INTRODUCTION & APPROACH TO SOLUTION **1. Identify/Define Problem:** Ability to identify and/or articulate a problem.	**10%**	
EACH PROJECT STAGE DEMO **2. Contextualize Problem:** Ability to understand the problem within a larger context (problem within a problem).	**20%**	
PROJECT SOLUTION/(WHY IS IT NOT WORKING) **3. Formulate Strategies for Solving a Problem:** Ability to identify strategies for solving problems (brainstorming, research, trial and error).	**20%**	
PRACTICAL PROJECT DESIGN & RESULTS (BASIC QUESTIONS) **4. Recognize and Consider Assumptions:** Ability to recognize and consider assumptions when solving a problem.	**10%**	

APPENDIX B: Report evaluation scheme

B. REPORT EVALUATION:	**MARK WEIGHT**	**OBTAINED MARK**
REPORT ON THE RESEARCH DONE, DEVELOPMENT AND APPROACH TO AND IMPLEMENTATION OF SOLUTION (STAGEWISE SOLUTION DEVELOPMENT)	**25%**	
5. Implement Solutions: Ability to implement a practical solution to address the problem.		
REPORT CONCLUSION & OVERALL PROJECT PRESENTATION	**15%**	
6. Evaluate Solution Implementation: Ability to evaluate solution implementation and impact (performance, limitations, cost (time and money), consequences of failure, risk).		