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 V1: CD40110 TWO-DISPLAY CRUISE SPEED CONTROL SIMULATION

Student Name: Surname and Initials

Student Number: Number

Lecturer: Dr N. Dube

Date: 19 June 2026

NOTE: PLEASE SAVE THE FILE AS,

Surname_Initials_StudentNumber_GA1_PROJECT_2026

Declaration

I, ..., declare that the contents of this document represent my own unaided work, and that the work submitted here has not been copied from other sources without proper referencing. All information obtained from other sources has been acknowledged. Furthermore, it represents my own opinions and not necessarily those of the Cape Peninsula University of Technology.

Full Names and Surname: ....

Student Number: ....

Signature: .... Date: .... Month .... Year ....

Summary/Abstract

This report presents Project V1 for the CSS370S GA1 cruise speed control simulation. The solution was developed using electronic components only and does not use a microcontroller or PLC. The design uses two CD40110 decade up/down counter/display driver integrated circuits to show a two-digit speed value from 00 to 10 on common-cathode seven-segment displays. Logic gates are used to separate the operating speed range into green indication for 00 to 05 and amber/yellow indication for 06 to 09. An XOR correction stage forces the green LED OFF when the system reaches the maximum value of 10. A 74LS85 comparator stage compares the current speed with the selected cruise speed, and the comparator output enables an NE555 astable timer so that the red LED flashes when the selected speed has been reached or exceeded.

The final Project V1 solution demonstrates the required display, indication, comparison and warning behaviour. The automatic reset/limit logic is included to allow 10 to be displayed as the maximum speed while preventing the next invalid state from remaining active. The circuit therefore satisfies the key project requirements of electronic-only implementation, speed display up to 10, green/yellow operating ranges, flashing red warning and cruise reset/limit behaviour.

Table of Contents

Table of Figures (TOF)

Table of Tables (TOT)

Table of Equations

Table of Acronyms

Table A: Acronyms used in the report

Acronym	Meaning
BCD	Binary-Coded Decimal
CC	Common Cathode
IC	Integrated Circuit
LED	Light Emitting Diode
LSB	Least Significant Bit
MSB	Most Significant Bit
NE555	555 timer integrated circuit
PLC	Programmable Logic Controller

1. Introduction

The CSS370S GA1 project requires the design of a vehicle cruise speed control simulation using practical electronic components only. The project brief specifically excludes microcontroller and PLC solutions and requires the design to be built and explained stage by stage. The purpose of the project is to demonstrate how counters, digital logic, comparator circuits and indicator stages can be combined to produce a functional control-system simulation.

For Project V1, the selected approach is a CD40110 two-display counter solution. The displayed current speed is controlled using UP, DOWN and reset input stages. The speed value is displayed from 00 to 10, while separate green, amber/yellow and flashing red indicators show the system state. The CD40110 is suitable for this version because it combines decade up/down counting with seven-segment display-driving functionality, reducing the number of separate display-driver components required (Texas Instruments, 1998).

Aim of the project

The aim of Project V1 is to design and document an electronic cruise speed control simulation that displays the current speed, separates the speed range into visual indicators, compares the current speed with a selected cruise speed and activates a flashing red warning when the selected speed is reached.

Problem statement

A practical electronic circuit is required to simulate cruise speed control without using software-based controllers. The design must show speeds from 00 to 10, indicate 00 to 05 with a green LED, indicate 06 to 09 with an amber/yellow LED, trigger a flashing red LED when the selected cruise speed has been reached, and include reset/limit logic that is not only a normal manual reset button.

The main requirements and their Project V1 implementation are summarized in Table 1 before the detailed system description is presented.

Table 1: Project V1 design requirement compliance summary

Project requirement	Project V1 implementation
Electronic circuit only	Implemented using CD40110 counters, 74LS85 comparators, logic gates, 2N3904 transistor, relay and NE555 timer.
No microcontroller / no PLC	The circuit uses only discrete logic and analogue timing components.
Green indicator for 0 to 5	Green LED is ON for displayed speeds 00 to 05.
Amber/yellow indicator for 6 to 9	Yellow LED is ON for displayed speeds 06 to 09.
Flashing red when selected cruise speed is reached	74LS85 comparator output enables the NE555 flashing LED circuit.
Maximum speed must show 10	The two-display CD40110 arrangement shows 10 as the maximum speed.
Cruise reset not only a reset button	Automatic 11 Reset and 99 Reset (Tens) logic is used as a limit/reset stage.

2. System description

Project V1 is based on a two-digit CD40110 counter circuit. The unit counter drives the unit display, and the ten counter allows the system to show the maximum speed of 10. The circuit in Figure 1 is the full Project V1 solution, including the display counters, green/yellow LED logic, comparator section, transistor/relay driver, NE555 flashing circuit, and automatic reset/limit logic.

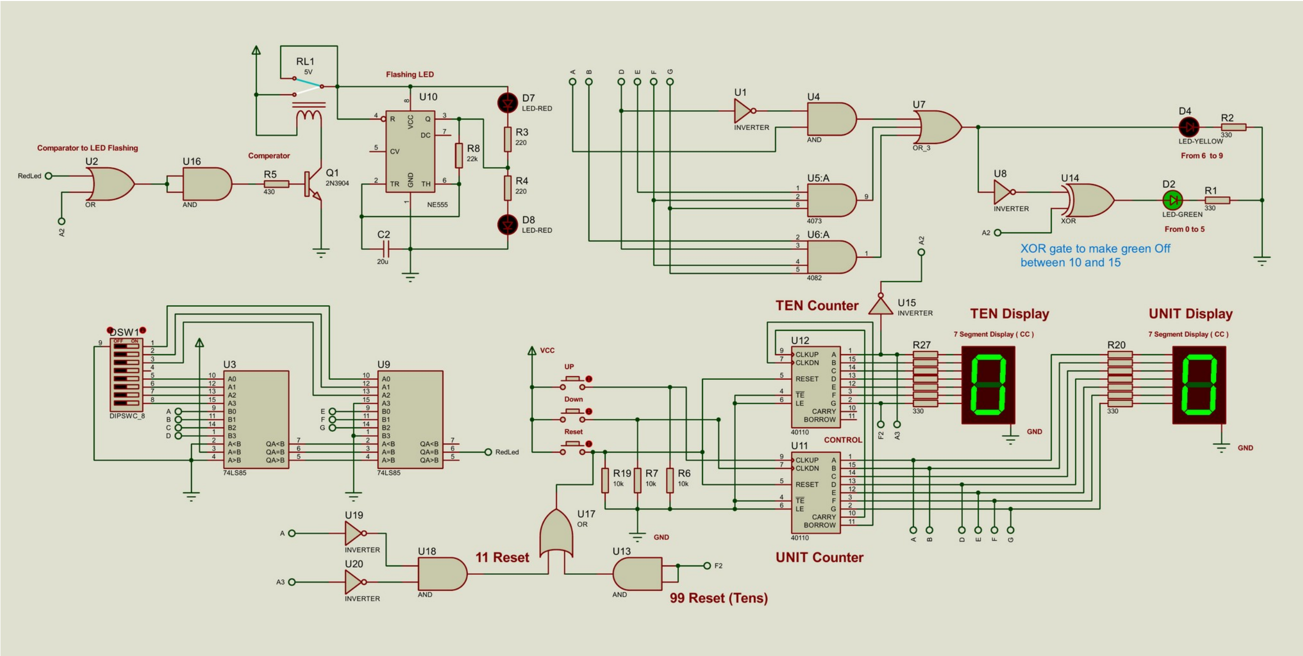

Figure 1: Project V1 CD40110 two-display cruise speed control circuit.

The added correction and reset notes are important because the green LED must not remain active when the two-display system reaches 10, and the count must not continue into invalid states. Figure 2 shows the additional XOR correction and reset/limit logic used in the updated truth tables.

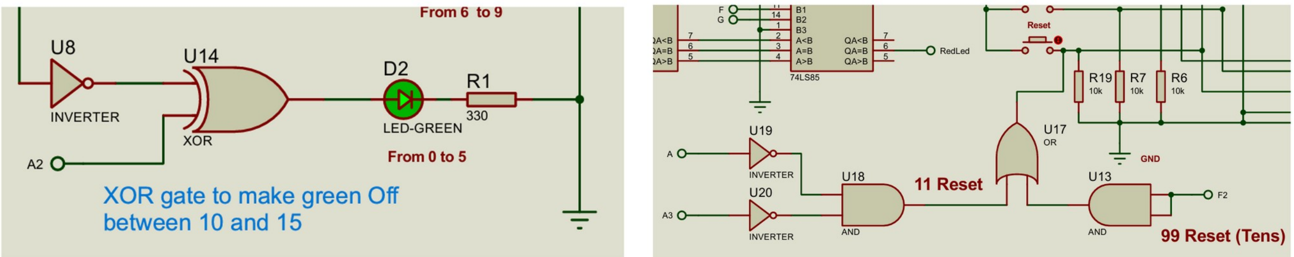

Figure 2: Added XOR correction and automatic reset logic notes for Project V1.

The main active components are summarized in Table 2. The table identifies how each major part supports the control-system operation.

Table 2: Main component function table for Project V1

Component / label	Function in Project V1
U11 and U12 CD40110	Unit and ten counters with direct common-cathode seven-segment display outputs.
U3 and U9 74LS85	Comparator stage used to check current speed against the selected cruise speed.
DSW1 DIP switch	Manual cruise-speed selection input.
U1, U4, U5:A, U6:A and U7	Logic network used to create the yellow/amber range signal.
U8 and U14	Inverter and XOR correction stage used to force green OFF when the speed reaches 10.
U18, U17 and U13	Automatic reset and limiting logic for the invalid 11 and high tens reset condition.
Q1, RL1 and U10 NE555	Transistor/relay enable stage and astable timer used to flash the red warning LED.

The system signal flow is summarized in Table 3. This gives a stage-by-stage view before each design stage is discussed.

Table 3: Overall signal flow for Project V1

Stage	Signal path	Purpose
Counting and display	UP/DOWN inputs -> CD40110 counters -> seven-segment displays	Shows the current speed from 00 to 10.
Range indication	CD40110 segment outputs -> logic gates -> green/yellow LEDs	Separates 00-05 from 06-09 and blocks green at 10.
Comparator decision	Current speed signals + DIP switch set speed -> 74LS85 comparators	Detects whether the selected cruise speed has been reached.
Red warning	Comparator output -> transistor/relay -> NE555 -> red LEDs	Flashes red when the current speed is equal to or above the selected speed.
Automatic limit reset	Invalid-state detection -> reset/limit path	Allows 10 to be displayed, then clears or blocks attempted invalid states.

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

The overall approach for Project V1 was to divide the cruise speed control simulation into independent stages. The counter and display stage was developed first because the displayed current speed is the main input to the rest of the logic. The LED range stage was then added to classify the displayed speed. The comparator stage was added to compare the current speed with the selected cruise speed, and the NE555 flashing stage was used to provide the red warning output.

This stage-by-stage approach follows the engineering design instruction that each stage should be tested independently before the complete circuit is assembled. The circuit is also suitable for laboratory presentation because the counting, display, range LEDs, comparator and flashing output can each be demonstrated separately.

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

In Project V1, the analog detector stage is represented by manual UP and DOWN pulse inputs rather than a separate analog sensor and ADC stage. This means the circuit focuses on the digital display, logic and warning-control behaviour. The UP input simulates increasing speed, the DOWN input simulates decreasing speed, and the reset/limit logic controls invalid speed states. This is an acceptable simulation approach for testing the digital cruise-speed control section, although a later version may add an actual analogue detector or ADC stage.

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

The increasing and decreasing speed function is produced using two CD40110 counters. The unit counter handles the unit digit from 0 to 9, while the ten counter allows the system to display 10. The CD40110 segment outputs are active-HIGH for the common-cathode displays, so a logic 1 turns the relevant segment ON.

Table 4 provides the CD40110 segment-output truth table used for the common-cathode displays. This table is needed because the same segment outputs are also reused by the LED range logic.

Table 4: CD40110 common-cathode display truth table

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

The full valid display range is shown in Table 5. The maximum displayed value is 10, and the indicator behaviour is included to link the counter output to the control requirements.

Table 5: Two-digit operating truth table for speeds 00 to 10

Speed	Ten digit	Unit digit	Green LED	Yellow LED	Red LED	Meaning
00	0	0	1	0	Comparator	Green range
01	0	1	1	0	Comparator	Green range
02	0	2	1	0	Comparator	Green range
03	0	3	1	0	Comparator	Green range
04	0	4	1	0	Comparator	Green range
05	0	5	1	0	Comparator	Green range
06	0	6	0	1	Comparator	Amber/yellow range
07	0	7	0	1	Comparator	Amber/yellow range
08	0	8	0	1	Comparator	Amber/yellow range
09	0	9	0	1	Comparator	Amber/yellow range
10	1	0	0	0	Comparator	Maximum speed displayed

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

The visual indicator stage uses green, yellow and red LEDs. The green LED represents the lower speed range from 00 to 05. The yellow LED represents the higher range from 06 to 09. The red LED is not controlled directly by the range logic; it is controlled by the comparator and flashes when the selected cruise speed has been reached or exceeded.

Equation 1 gives the yellow range condition formed from the CD40110 segment logic terms.

Yellow = Y1 + Y2 + Y3, where Y1 = A.NOT D, Y2 = E.F.G, and Y3 = A.B.F.G

Equation 2 shows the corrected green output. The T10 signal is active when the ten-display state reaches 10.

Green = (NOT Yellow) XOR T10

The LED logic truth table is shown in Table 6. It demonstrates that the XOR correction forces the green LED OFF when the maximum speed 10 is displayed.

Table 6: Green/yellow LED logic truth table

Speed	T10	Unit digit	Yellow	Raw Green	Corrected Green	Result
00	0	0	0	1	1	Green ON
01	0	1	0	1	1	Green ON
02	0	2	0	1	1	Green ON
03	0	3	0	1	1	Green ON
04	0	4	0	1	1	Green ON
05	0	5	0	1	1	Green ON
06	0	6	1	0	0	Yellow ON
07	0	7	1	0	0	Yellow ON
08	0	8	1	0	0	Yellow ON
09	0	9	1	0	0	Yellow ON
10	1	0	0	1	0	Both OFF

Equation 3 defines the comparator warning output. The same logic is used to enable the NE555 flashing red LED circuit.

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

Table 8 gives the comparator truth table. The flashing warning becomes active when F is HIGH.

Table 8: Comparator 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

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

The final Project V1 design combines the counter/display stage, LED range logic, comparator stage, flashing timer and reset/limit logic into one complete electronic control-system simulation. The comparator uses the selected cruise speed as the reference, while the displayed current speed acts as the controlled variable. When the current speed reaches the selected value, the NE555 warning stage is enabled.

Table 7 presents the automatic maximum-speed limit and reset behaviour. This stage supports the project requirement that the cruise reset must not be only a normal reset button.

Table 7: Automatic maximum-speed limit and reset truth table

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

The NE555 warning behaviour is summarized in Table 9. The timer stage produces the visible flashing red warning after the comparator enables the warning path.

Table 9: NE555 flashing red LED operation table

Comparator F	Q1 / relay stage	NE555 state	Red LED state
0	OFF / relay not energised	Disabled or held reset	OFF
1	ON / relay energised	Enabled astable mode	Flashing

3. Observations and results

The Project V1 simulation satisfies the main display and indicator requirements. The two CD40110 counters allow a two-digit display from 00 to 10. The green LED is active for 00 to 05, and the yellow LED is active for 06 to 09. When the system reaches 10, the XOR correction prevents the green LED from turning back ON because 10 has a unit digit of 0 but is not part of the 00 to 05 green range.

The comparator stage provides the required cruise-speed decision. When the displayed current speed is lower than the selected set speed, the red LED remains OFF. When the displayed speed is equal to or higher than the selected set speed, the comparator output enables the transistor/relay and NE555 flashing stage. This means the red LED flashes at the set speed and continues flashing until the maximum value is reached.

The automatic reset/limit logic also supports the required maximum-speed behaviour. The circuit allows 10 to be displayed, but an attempted invalid 11 state activates the reset/limit path. The 99 Reset (Tens) logic prevents unwanted continuation of the tens display if the counter is driven beyond the intended simulation range.

4. Conclusion

Project V1 demonstrates a complete electronic cruise speed control simulation using CD40110 counters, logic gates, comparators and an NE555 flashing stage. The design achieves the required green indication for 00 to 05, yellow indication for 06 to 09, flashing red warning when the selected cruise speed is reached, and maximum display value of 10. The added XOR correction and automatic reset/limit logic improve the design by preventing the green LED from being active at 10 and by clearing invalid count states after the maximum speed.

The main limitation of Project V1 is that the analog detector stage is represented by manual pulse inputs rather than by a real sensor and ADC stage. However, the digital logic, display and warning-control stages are clearly demonstrated and can be tested independently. A future version can improve the design by adding a proper analog detector and signal-conditioning stage before the digital display/control logic.

Bibliography

Cape Peninsula University of Technology. (2026). CSS370S GA1 Project 2026 Brief. Department of Electrical, Electronic and Computer Engineering.

Texas Instruments. (1998). CD40110B CMOS Decade Up-Down Counter/Latch/Display Driver Data Sheet. https://www.ti.com/product/CD40110B

Texas Instruments. (1988). SN5485, SN54LS85, SN7485, SN74LS85 4-Bit Magnitude Comparators Data Sheet. https://www.ti.com/lit/gpn/SN54LS85

Texas Instruments. (2025). NE555 Precision Timers Data Sheet. https://www.ti.com/product/NE555

onsemi. (n.d.). 2N3903, 2N3904 NPN Silicon Transistors Data Sheet. https://www.onsemi.com/download/data-sheet/pdf/2n3903-d.pdf

Appendices

Appendix A: Project V1 Truth Tables

Appendix A contains the truth-table material used to verify the Project V1 operation. The full truth-table PDF is supplied separately and the key tables are included in the main report as Tables 4 to 9.

Appendix B: Original Circuit Schematic

Appendix B refers to the original Project V1 schematic file supplied as One Counter.PDF. The schematic is reproduced in Figure 1 for direct reference in the main report.

Appendix C: Practical and Report Evaluation Scheme

The practical and report evaluation scheme should be attached or completed according to the lecturer instructions before final submission.