**Faculty of Engineering and Built Environment**

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Bachelor of Engineering Technology: Electrical Engineering

# CONTROL SYSTEMS 3 (CSS370S)

## FINAL PROJECT PART 1: GA1 EVALUATION

## PROJECT V03: CD4029 / 74LS47 TWO-DISPLAY CRUISE SPEED CONTROL SYSTEM

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

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Date: 19 June 2026

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## Declaration

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## Summary/Abstract

This report presents Project V03 of the CSS370S GA1 cruise speed control simulation. The project brief requires a practical electronic control-system solution with no microcontroller and no PLC. The required system must show a green indicator for speeds 0 to 5, an amber/yellow indicator for speeds 6 to 9, a flashing red indicator when the selected cruise speed is reached, a maximum displayed speed of 10, and an automatic cruise reset/limit action that is not only a manual reset button.

Project V03 uses two CD4029 BCD up/down counters, two 74LS47 BCD-to-seven-segment drivers, two common-anode seven-segment displays, a 74LS85 magnitude comparator, gate-level range logic, a 2N3904 transistor/relay driver stage, and an NE555 astable flashing red LED circuit. The updated logic also uses an XOR correction so that the green LED is forced OFF when the display reaches 10.

The solution was analysed using the provided circuit and the truth tables for the counter, display driver, green/yellow indicator logic, comparator operation, NE555 flashing stage, and maximum-speed reset function. The analysis confirms that Project V03 satisfies the main project requirements using electronic components only.

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## Table of Acronyms

**Table A: Acronyms used in the report**

| Acronym | Meaning |
| --- | --- |
| BCD | Binary Coded Decimal |
| LED | Light Emitting Diode |
| IC | Integrated Circuit |
| LSB | Least Significant Bit |
| MSB | Most Significant Bit |
| VCC | Positive supply voltage |
| GND | Ground reference |
| GA1 | Graduate Attribute 1: Problem Solving |

## 1. Introduction

The CSS370S GA1 project is performed to demonstrate problem solving through the design and documentation of an electronic cruise speed control simulation. The project requires students to use practical electronic components and to build the system stage by stage. Software-based control using a microcontroller or PLC is not used.

The aim of Project V03 is to design and document a two-display cruise speed control circuit that can represent the current speed from 00 to 10. The circuit must indicate the lower speed range using a green LED, the higher range using a yellow/amber LED, and the selected cruise-speed condition using a flashing red LED.

The problem addressed by this design is how to implement the required cruise speed behaviour using only counters, decoders, digital logic, a comparator, and a timer circuit. The solution must also prevent invalid display values beyond the required maximum speed. This makes the reset and limiting logic an important part of the project rather than only a start-up reset.

Project V03 satisfies the main functional requirements in simulation. The CD4029 counters generate the speed count, the 74LS47 drivers display the count on common-anode seven-segment displays, the logic gates generate the green and yellow output ranges, and the 74LS85/NE555 section produces the flashing red warning when the selected cruise speed is reached.

## 2. System description

Project V03 is a two-display electronic speed-control simulation. The circuit uses a unit counter and a tens counter so that the display can show the maximum value of 10. The CD4029 counter is suitable for the counter stage because it operates as a presettable up/down counter with binary or decade counting modes and carry support [1].

Figure 1 presents the complete Project V03 circuit used for this report. The circuit shows the two CD4029 counters, the 74LS47 common-anode display driver section, the range indicator logic, the 74LS85 comparator, the transistor/relay driver and the NE555 flashing red LED stage.

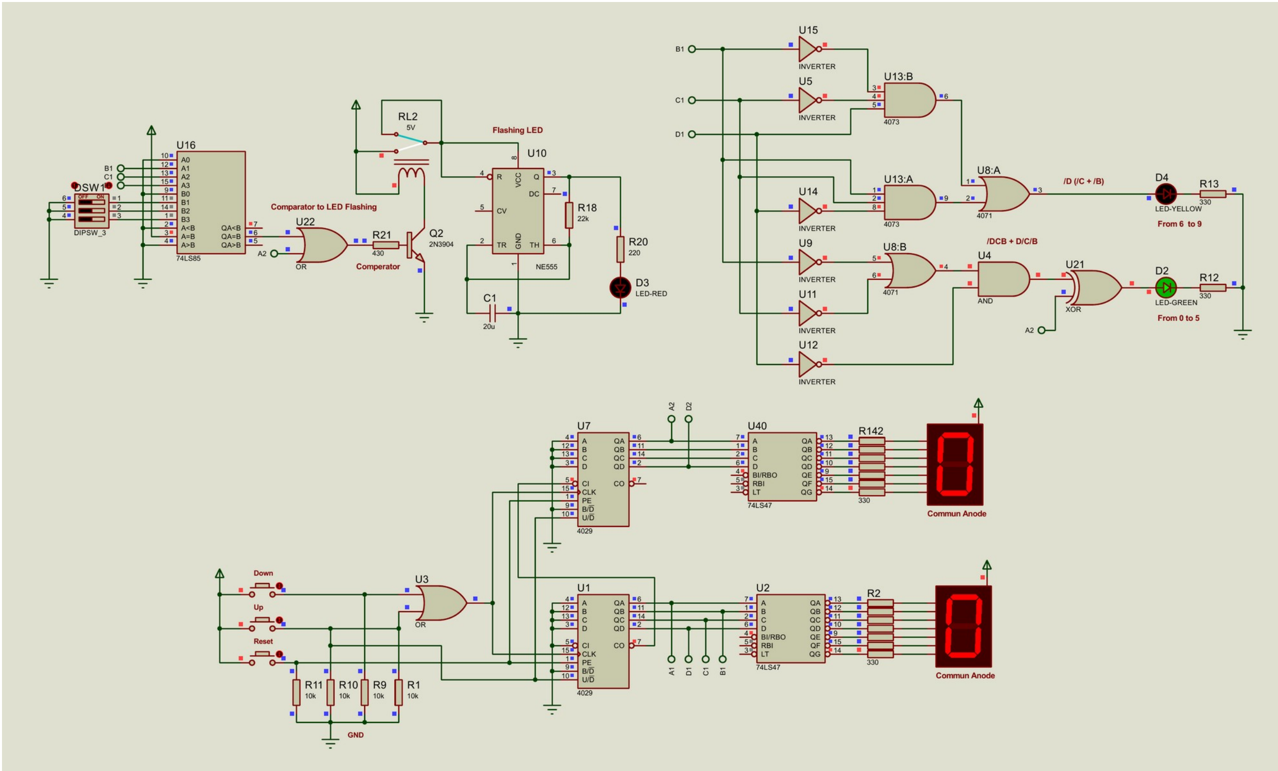


*Figure 1: Project V03 CD4029 / 74LS47 cruise speed control circuit*

Figure 2 presents the added XOR correction used for the green indicator. This correction is required because the unit digit is 0 when the displayed value reaches 10. Without the correction, the unit digit can incorrectly satisfy the green range condition even though 10 is not part of the 0 to 5 green range.

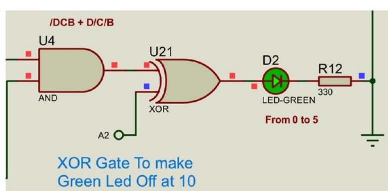


Figure 2: Added XOR correction. The XOR gate uses the ten-state signal A2 to force the green LED OFF at 10.

Updated CD4029 + 74LS47 Cruise Speed Control Truth Tables

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*Figure 2: XOR green LED correction used in Project V03*

Table 1 defines the operating conditions used to evaluate the circuit. These conditions come directly from the project requirement and are used throughout the report as the basis for the truth-table verification.

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

| Condition | Required output |
|---|---|
| Current speed = 0 to 5 | Green LED ON, yellow LED OFF. Red LED depends on the comparator set speed. |
| Current speed = 6 to 9 | Yellow/amber LED ON, green LED OFF. Red LED depends on the comparator set speed. |
| Current speed reaches selected set speed | Comparator output enables the NE555 stage and the red LED flashes. |
| Current speed = 10 | Maximum speed is displayed. Green and yellow LEDs are OFF. |
| Attempted count above 10 | Automatic limit/reset action prevents the display from continuing into invalid values. |

Table 2 identifies the main component groups used in Project V03. The table is included before the detailed stages so that the role of each section is clear before the system is analysed.

**Table 2: Main component function table for Project V03**

| Component / label | Circuit part | Purpose in this solution |
|---|---|---|
| U1 | CD4029 | Unit BCD up/down counter used for the unit speed digit. |
| U7 | CD4029 | Tens BCD up/down counter used to show 10. |
| U2 and U40 | 74LS47 | BCD-to-seven-segment decoder/drivers for common-anode displays. |
| U16 | 74LS85 | Compares the displayed current speed with the selected cruise set speed. |
| DSW1 | DIP switch | Manual set-speed input for the comparator. |
| U13:A, U13:B | CD4073 AND gates | Create the yellow/amber range terms. |
| U8:A, U8:B | CD4071 OR gates | Combine the LED logic terms. |
| U4 and U21 | AND and XOR logic | Produce the corrected green LED output and force green OFF at 10. |
| Q2, RL2 and U10 | 2N3904, relay and NE555 | Enable and flash the red warning LED when the comparator condition is reached. |

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

The overall solution was developed as a staged electronic circuit. The first stage is the two-digit counter and display section because the simulated current speed must be visible before the indicator and warning stages can be tested.

The unit CD4029 counter produces the 0 to 9 count, while the tens CD4029 counter allows the display to show 10. The 74LS47 drivers decode the BCD counter outputs into seven-segment outputs for common-anode displays. The system is therefore able to show the required maximum speed instead of stopping at 9.

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

Project V03 represents the cruise speed using push-button count pulses rather than a physical vehicle-speed sensor. The analog detector stage is therefore represented by the manual speed input section in the simulation.

In a practical extension, a detector or sensor circuit could generate a voltage proportional to speed, followed by signal conditioning and conversion into the digital counter/display stage. For this project version, the electronic count/display and logic stages were prioritised because they demonstrate the required control behaviour.

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

The increasing and decreasing speed function is produced by the UP and DOWN control paths connected to the CD4029 counters. A pulse on the UP path increases the displayed speed and a pulse on the DOWN path decreases the displayed speed.

The carry and limiting behaviour is important because the system must show 10 but must not continue into invalid values. The design uses the tens signal and correction logic so that the circuit can display 10 and then prevent or reset the next invalid count.

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

The display and alarm stage includes the two seven-segment displays, the green LED, the yellow/amber LED and the red flashing LED. The green/yellow outputs are derived from the BCD logic and corrected using the XOR stage. This ensures that green is active only from 0 to 5 and yellow is active only from 6 to 9.

The red flashing output is independent of the green/yellow range logic. The 74LS85 comparator checks whether the current speed has reached or exceeded the selected set speed. When this condition is true, the comparator output enables the 2N3904 transistor/relay stage and the NE555 timer flashes the red LED.

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

The final system combines the counter, display, LED range, comparator, flashing red warning and reset/limit sections. This demonstrates a complete electronic solution to the project problem without using a microcontroller or PLC.

The approach is suitable for the GA1 problem-solving requirement because the design was divided into smaller stages, each stage was linked to a truth table, and the final operation was verified using the required speed ranges and maximum speed condition.

## 3. Observations and results

Table 3 shows the relevant CD4029 pins and their use in Project V03. This clarifies how the counter is connected before the count and display truth tables are evaluated.

**Table 3: CD4029 pin and connection table**

| CD4029 pin | Label | Connection / use in this design |
|---|---|---|
| 15 | CLK | Clock pulse from the UP/DOWN logic through U3. |
| 10 | U/D | Selects count direction for increasing or decreasing speed. |
| 9 | B/D | Set for decade/BCD counting mode. |
| 1 | PE | Preset enable held inactive during normal counting. |
| 5 | CI | Carry/count-enable input for single-stage or cascaded operation. |
| 6 | QA / A | Least significant BCD output to 74LS47 and logic section. |
| 11 | QB / B | Second BCD output to 74LS47 and logic section. |
| 14 | QC / C | Third BCD output to 74LS47 and logic section. |
| 2 | QD / D | Most significant BCD output to 74LS47 and logic section. |
| 7 | CO | Carry output used for cascading the unit counter to the tens counter. |

Table 4 summarises the UP, DOWN and reset operation. The manual reset clears the display, while the cruise reset or automatic limit condition is used to prevent invalid counting beyond the allowed range.

**Table 4: UP, DOWN and reset control truth table**

| DOWN | UP | RESET / cruise reset | Clock from U3 | Direction | Counter action | Display result |
|---|---|---|---|---|---|---|
| 0 | 0 | 0 | 0 | Previous state | Hold | Same value remains displayed |
| 0 | 1 pulse | 0 | 1 pulse | Up | Count up | Display increases by 1 |
| 1 pulse | 0 | 0 | 1 pulse | Down | Count down | Display decreases by 1 |
| 1 | 1 | 0 | 1 | Invalid | Not recommended | May behave incorrectly |
| X | X | 1 | X | X | Reset / clear | Display returns to 00 |

Table 5 confirms the standard BCD sequence produced by one CD4029 counter in decade mode.

**Table 5: CD4029 BCD counter truth table**

| Decimal digit | D | C | B | A | BCD DCBA |
|---|---|---|---|---|---|
| 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 6 gives the 74LS47 common-anode seven-segment truth table. In this table, logic 0 means the segment is ON and logic 1 means the segment is OFF.

**Table 6: 74LS47 common-anode seven-segment truth table**

| Decimal | 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 |

Table 7 links the two CD4029 counters to the displayed speed range. The table confirms that the valid sequence reaches 10 as the project maximum.

**Table 7: Two-display 00 to 10 operating truth table**

| Speed | Tens DCBA | Unit DCBA | Tens display | Unit display | A2 | Green | Yellow | State |
|---|---|---|---|---|---|---|---|---|
| 0 | 0000 | 0000 | 0 | 0 | 0 | 1 | 0 | 0–5 green |
| 1 | 0000 | 0001 | 0 | 1 | 0 | 1 | 0 | 0–5 green |
| 2 | 0000 | 0010 | 0 | 2 | 0 | 1 | 0 | 0–5 green |
| 3 | 0000 | 0011 | 0 | 3 | 0 | 1 | 0 | 0–5 green |
| 4 | 0000 | 0100 | 0 | 4 | 0 | 1 | 0 | 0–5 green |
| 5 | 0000 | 0101 | 0 | 5 | 0 | 1 | 0 | 0–5 green |
| 6 | 0000 | 0110 | 0 | 6 | 0 | 0 | 1 | 6–9 yellow |
| 7 | 0000 | 0111 | 0 | 7 | 0 | 0 | 1 | 6–9 yellow |
| 8 | 0000 | 1000 | 0 | 8 | 0 | 0 | 1 | 6–9 yellow |
| 9 | 0000 | 1001 | 0 | 9 | 0 | 0 | 1 | 6–9 yellow |
| 10 | 0001 | 0000 | 1 | 0 | 1 | 0 | 0 | Maximum speed 10 |

Table 8 verifies the green and yellow LED range logic. The XOR correction uses A2 to keep the green LED OFF when the display reaches 10.

**Table 8: Green/yellow LED range logic truth table**

| Speed | A2 | Unit DCBA | Low-range base | Yellow | Final green | LED result |
|---|---|---|---|---|---|---|
| 0 | 0 | 0000 | 1 | 0 | 1 | Green ON |
| 1 | 0 | 0001 | 1 | 0 | 1 | Green ON |
| 2 | 0 | 0010 | 1 | 0 | 1 | Green ON |
| 3 | 0 | 0011 | 1 | 0 | 1 | Green ON |
| 4 | 0 | 0100 | 1 | 0 | 1 | Green ON |
| 5 | 0 | 0101 | 1 | 0 | 1 | Green ON |
| 6 | 0 | 0110 | 0 | 1 | 0 | Yellow ON |
| 7 | 0 | 0111 | 0 | 1 | 0 | Yellow ON |
| 8 | 0 | 1000 | 0 | 1 | 0 | Yellow ON |
| 9 | 0 | 1001 | 0 | 1 | 0 | Yellow ON |
| 10 | 1 | 0000 | 1 | 0 | 0 | No green/yellow |

Table 9 gives the comparator decision used by the red flashing warning section. The 74LS85 magnitude comparator provides A>B, A=B and A<B outputs, which makes it suitable for the cruise-speed comparison stage [3].

**Table 9: 74LS85 comparator truth table**

| Current speed condition | A > B | A = B | A < B | F = (A>B)+(A=B) | Red LED state |
|---|---|---|---|---|---|
| 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 shows the NE555 flashing stage operation. The NE555 is used in astable mode so that the red LED flashes when the comparator enables the warning stage [4].

**Table 10: NE555 flashing red LED truth table**

| F from comparator | Q2 transistor | Relay RL2 / NE555 reset | NE555 state | Red LED |
|---|---|---|---|---|
| 0 | OFF | Relay not energised / reset inactive | Disabled | OFF |
| 1 | ON | Relay energised / reset released | Astable flashing | Flashing |

Table 11 summarises the final Project V03 operating behaviour. The result confirms that the required green, yellow, red and maximum-speed behaviours are satisfied.

**Table 11: Final operating summary**

| Condition | Green | Yellow | Flashing red | Meaning |
|---|---|---|---|---|
| Speed 0 to 5 | ON | OFF | Depends on comparator | Low/normal speed range |
| Speed 6 to 9 | OFF | ON | Depends on comparator | Higher speed range before maximum |
| Speed = selected set speed | Range LED works | Range LED works | Flashing | Cruise speed has been reached |
| Speed > selected set speed | Range LED works | Range LED works | Flashing | Speed has passed set speed |
| Speed = 10 | OFF | OFF | Flashing if comparator active | Maximum speed displayed |
| Speed attempts to go above 10 | OFF | OFF | Reset/controlled | Automatic reset prevents invalid display |

## 4. Conclusion

Project V03 demonstrates a working electronic cruise speed control simulation using CD4029 counters, 74LS47 display drivers, a 74LS85 comparator, logic gates, a 2N3904 transistor/relay stage and an NE555 flashing circuit. The design avoids microcontrollers and PLCs, which matches the project requirement.

The truth-table analysis confirms that the green LED turns ON for speeds 0 to 5, the yellow/amber LED turns ON for speeds 6 to 9, and both range LEDs are OFF at the maximum speed of 10. The XOR correction is important because it prevents the unit digit 0 at speed 10 from incorrectly activating the green LED.

The comparator and NE555 section produces the required flashing red warning when the current speed reaches or exceeds the selected set speed. The automatic limit/reset logic supports the project requirement that the maximum speed 10 must be displayed without allowing the circuit to continue into invalid speed values.

## Bibliography

[1] Texas Instruments, “CD4029B CMOS presettable up/down counter datasheet,” Texas Instruments.

[2] Texas Instruments, “SN74LS47 BCD-to-seven-segment decoders/drivers datasheet,” Texas Instruments.

[3] Texas Instruments, “SN74LS85 4-bit magnitude comparator datasheet,” Texas Instruments.

[4] Texas Instruments, “NE555 precision timer datasheet,” Texas Instruments.

[5] onsemi, “2N3904 NPN general-purpose amplifier datasheet,” onsemi.

## Appendices

### APPENDIX A: Truth-table pack used for Project V03

The detailed Project V03 truth-table pack is attached separately as project_4029_truth_tables_updated.pdf. The main report includes the most important truth tables needed to explain the operation of the circuit.

### APPENDIX B: Practical evaluation scheme

This appendix follows the GA1 practical evaluation focus: identify the problem, formulate a strategy, implement the solution, and evaluate the result.

### APPENDIX C: Report evaluation scheme

This appendix follows the report evaluation focus: stage-wise development, implementation discussion, observations, limitations, conclusion and professional presentation.