

Embedded C Essay

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Introduction

This project uses a PIC 8 bit Microcontroller (PIC16F877A) and Proteus, the task is to design an automotive cooling system status simulator using three buttons to simulate Engine Start (SW1), Coolant Sensor Trigger (SW2) and Fan Activation (SW3) with each switch triggering the next stage of operation when pressed in the correct order. Use three LEDs to indicate the system status with LED1 for Start Signal, LED2 for Coolant Confirmation and LED3 as an Alert Indicator. A motor is used to simulate a radiator fan and should be controlled via 2 output pins to simulate forward operation. Once the fan operation cycle is complete blink the alert LED three times with a 100ms interval indicating the system is moving to shutdown. All system messages must be displayed on an LCD Module (connected to PORTD in 4-bit mode) such as:

- System Ready
- Engine Started
- Coolant OK
- Fan Activated
- Motor Running
- ALERT!
- Shutdown Done



Each message must also be sent via UART to a Virtual Terminal within Proteus for real-time system monitoring.

Background Research

The components used with this system include the PIC16F877A microcontroller which is an 8 bit controller with 40 or 44 pins, this project uses the 40 pin version. [1] This microcontroller operates at 20MHz and has 5 Input / Output (I/O) Ports A-E. It supports serial communication via Universal Synchronous Asynchronous Receiver Transmitter (USART) and Universal Asynchronous Receiver Transmitter (UART) [2] which is used for the Virtual terminal in Proteus but can also support Inter Integrated Circuit (I²C) and Serial Peripheral Interface (SPI). This microcontroller is widely used for Embedded Projects due to the low power consumption and ease of use and can be used for motor control [3], robotic arms [4] and Water Quality Monitoring Systems [5] to name a few uses. Sensors can be used in conjunction with the PIC with temperature sensors, ultrasonic sensor and light dependant resistors which can be used to create a smart system that can adapt light output dependant on the light levels within a room [6]. Another use that aligns with the current project is using the PIC to control windscreen wipers, headlight automation and smart window features [7] [8]. Another paper looked at using a PIC for a cooling system utilising LM35 temperature sensors to control motors using pulse width modulation (PWM) to improve power management, feedback was provided through LED's and an LCD display which is similar to this project [9].

The LCD Module is used within this circuit to display the messages; to minimise the number of wires required it is connected in 4-bit mode using 4 pins as data transfer as opposed to 8 and 3 pins for Register Select (RS), Read / Write (R/W) and Enable (E). The remaining pins are used for power and backlight. A variable resistor (10k) is used on the power connections to control the contrast pin (V₀) by acting as a voltage divider allowing the contrast of the LCD to be changed as required to aid readability [10]. A crystal oscillator is used in conjunction with 2 capacitors (22pF) to provide a highly accurate clock for the PIC [11]. This is done by using the mechanical resonance of the crystal and measuring the frequency produces and using it as a time reference, the two capacitors must be chosen carefully to ensure correct operation and the desired frequency is produced [12]. To

Circuit Design



2

Flowchart

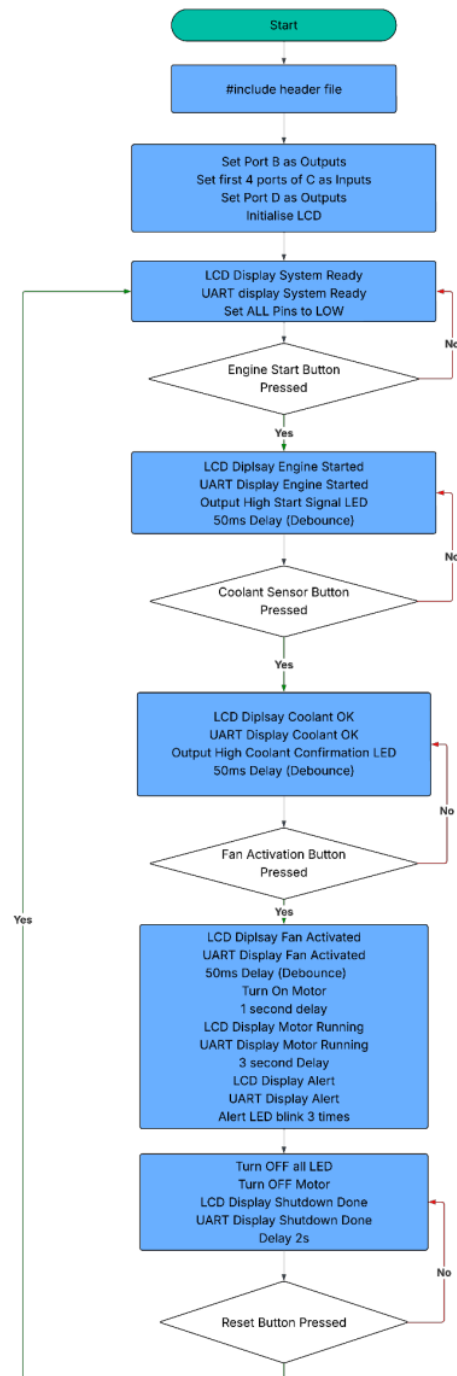


Figure 2 - Flowchart of Engine System Program

Screen Dumps

After building the system in Proteus and writing the program as the flowchart does there were slight changes made to the code discussed in the testing section. The first screenshot below shows the system ready with both the LCD display and the UART shown.

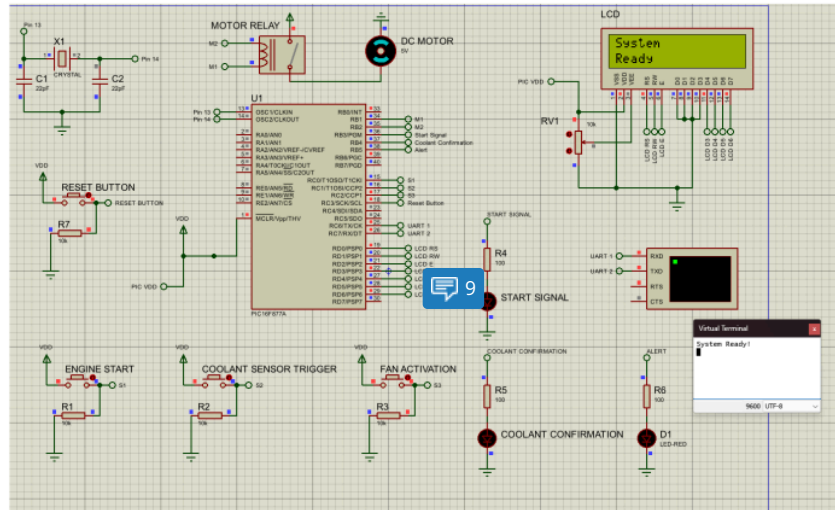


Figure 3 - System Ready

The next screenshot, figure 4, shows after the engine start button has been pressed with the LED illuminated and the message updated to say engine started.

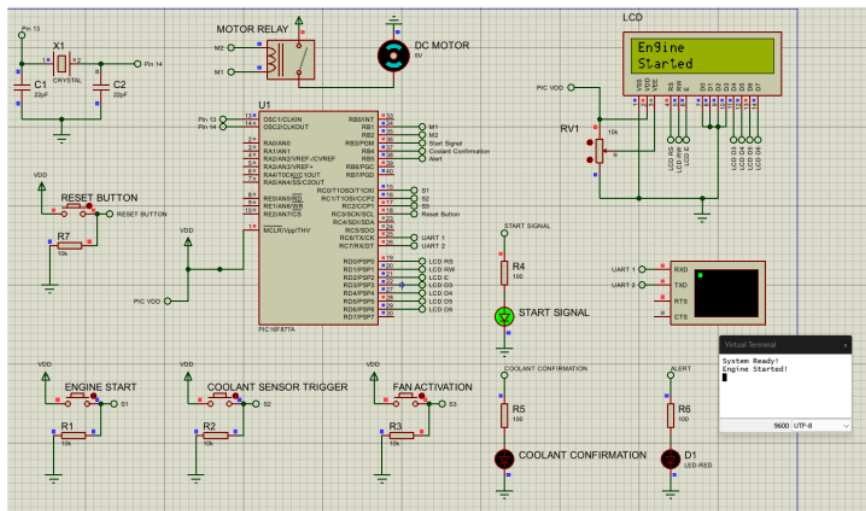


Figure 4 - Engine Started

Once the coolant sensor trigger is pressed the LED illuminates and the LCD and UART display are updated accordingly.

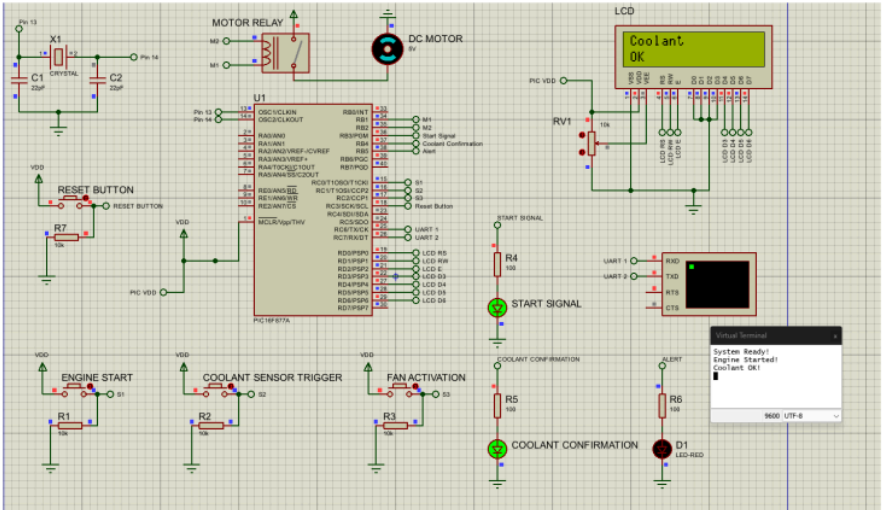


Figure 5 - Coolant OK

Once the fan is activated the motor can be seen turning, the outputs on the relay also show that there would be current flowing and pulling in the contact to activate the fan.

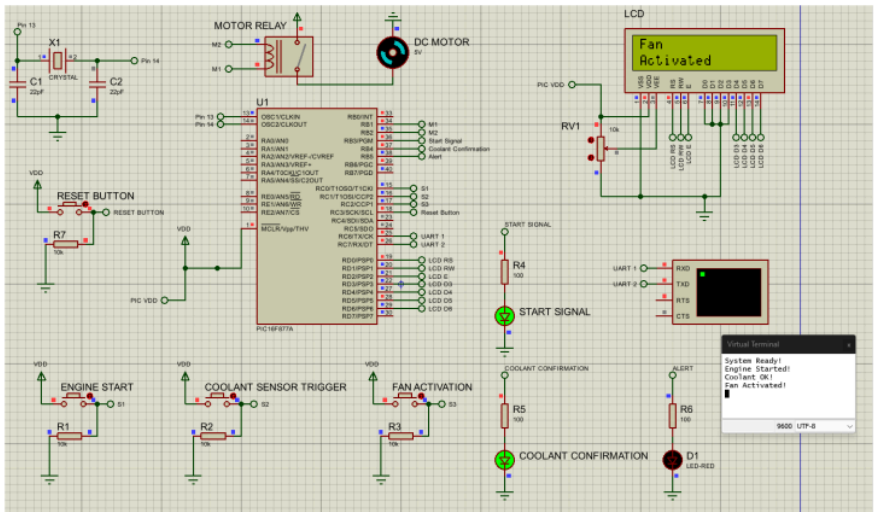
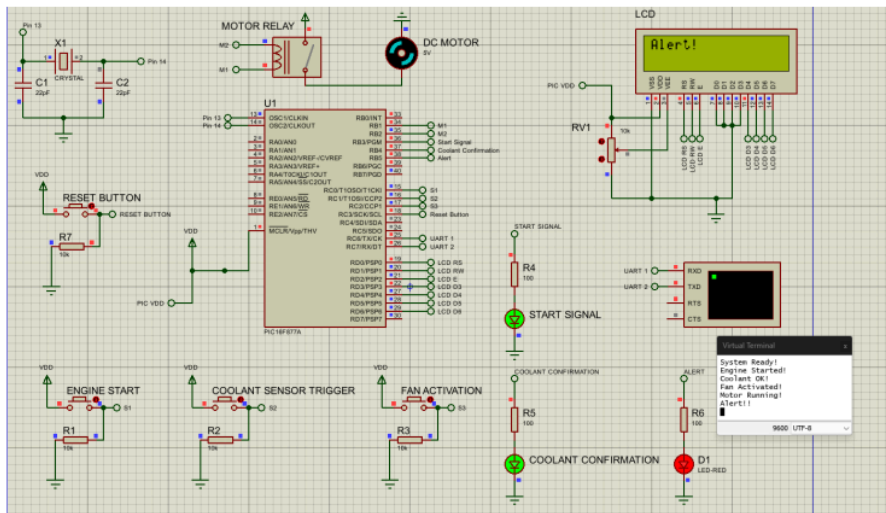
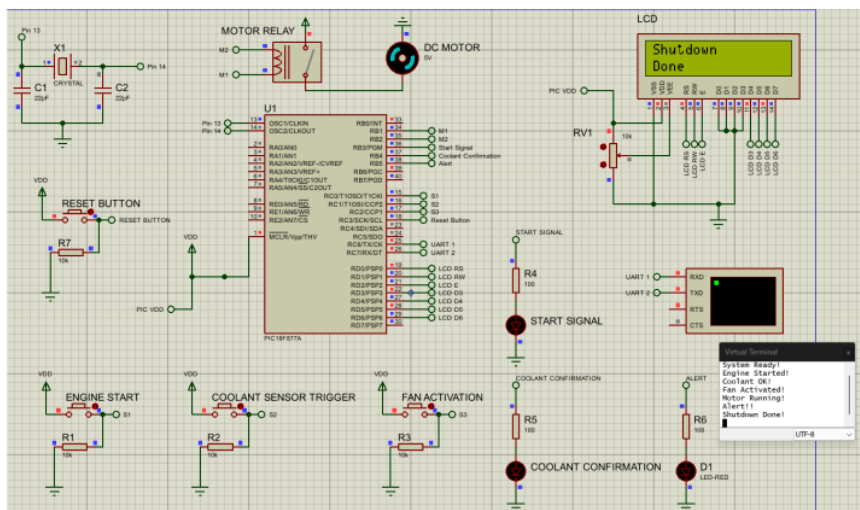


Figure 6 - Fan Activated



The above figure shows the alert LED flashing and the LCD and UART showing Alert, after this shutdown is complete and the corresponding display capture can be seen in figure 8 with all LED's off and both displays showing shutdown complete.



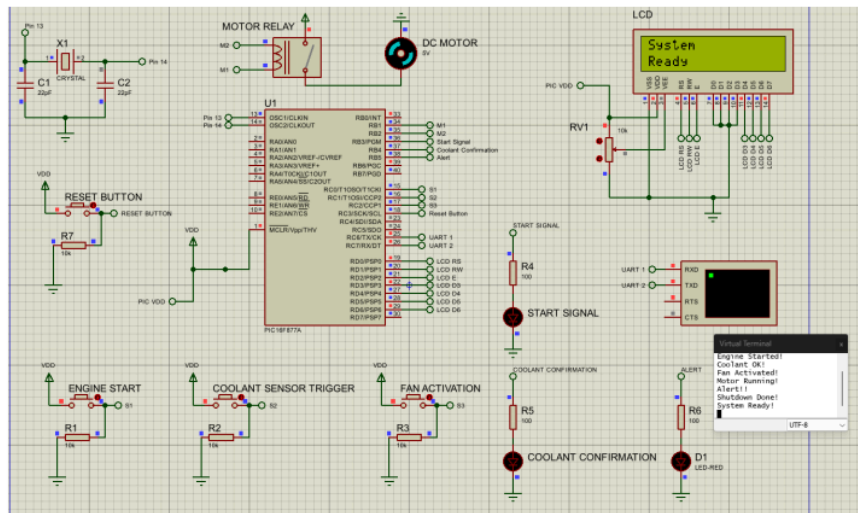


Figure 9 - Reset

A reset button was added extra to the circuit so when pressed it would reset the system to the beginning and the system would state 'System Ready'.

Testing Details

During initial testing the engine system worked as intended with all buttons producing the expected outcome and only in the correct order except for the reset switch. The way the program was initially written had not used a while loop for the reset button only an if statement and therefore when pressed it would reset the system but then after the first use it stopped working and the program ended. The use of a loop the section was used and the button sequence moved to the beginning and named start process enabling that section of code to be called whenever required and minimise the need to repeat code. The Start Process section is a long piece of code so calling it as a function reduced coding significantly.

```
68 while (True)
69 if (input(Reset_Button)) // Reset Button Pressed
70 {
71   StartProcess(); //Goes to StartProcess
72 }
73 else
74 {
75   output_low(Motor_Ini1);
76   output_low(Motor_Ini2);
77   output_low(LED_StartSignal);
78   output_low(LED_CoolantConfirmation);
79   output_low(LED_Alert);
80   //Above sets all outputs as low
```

Figure 10 - While Loop

Conclusion

To conclude the engine coolant system and button sequence run as expected. A potential change that would be used next time would be the addition of a 7805 voltage regulator to ensure the 5V supply was maintained to reduce the risk of damage to the PIC from high voltage. There would also be a slight change to the code with the section of code setting all outputs to low being placed into a function and then called whenever required thus reducing the amount of code being re-written unnecessarily.



References

- [1] Microchip, "PIC16F877A," 29 03 2026. [Online]. Available: <https://www.microchip.com/en-us/product/pic16f877a>. [Accessed 29 03 2026].
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- [3] T. A. Arun, T. S. Madhukar and J. Deka, "Speed Control of DC Motor using," *Multidisciplinary Journal of Research in Engineering and Technology*, vol. 1, no. 2, pp. 223-234, 2014.
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- [9] A. Tiwari, P. Bhide and V. Gohil, "Adaptive Thermal Control using Dual Motors and PIC16F877A Microcontroller in Multi-Zone Environments," in *8th International Conference on Computing Methodologies and Communication (ICCMC)*, Erode, 2025.
- [10] E. M. Schwartz and J. A. Martiney, "4-bit LCD Interface Notes," University of Florida, Florida, 25.
- [11] R. M. Cerda, *Understanding Quartz Crystals and Oscillators*, Boston: Artech House, 2014.
- [12] J. R. Vig, "Introduction to Quartz Frequency," US Army Laboratory Command, Fort Monomuth, 1992.

Embedded C Essay

GRADEMARK REPORT

FINAL GRADE

GENERAL COMMENTS

72/100

PAGE 1

PAGE 2

PAGE 3

PAGE 4



Comment 1 | Engagement with Literature(10)

A neat description of what the design is about is provided, which is good.



Comment 2 | Engagement with Literature(10)

Adding the concept of the cooling system in the literature review is required.



Comment 3 | Engagement with Literature(10)

The literature review should include points related to the design and provide a critical comparison with similar designs discussed in journal papers and other relevant sources.



Comment 4 | Cognitive & Intellectual (25)

It is good to see the features of the PIC microcontroller discussed, including power-related aspects. However, it is also necessary to include details about the advantages of the pins and memory capacity.



Comment 5 | Knowledge & Understanding(20)

Some of the I/O devices are explained well; however, it is also essential to explain the virtual terminal and other components used in the design.

PAGE 5



Comment 6 | Knowledge & Understanding(20)

The circuit design is neat, and the construction details are well explained.

PAGE 6



Comment 7 | Cognitive & Intellectual (25)

The flowchart provided is neat and clear.

PAGE 7



Comment 8 | Cognitive & Intellectual (25)

Clear screenshots and testing evidence are included, which is appreciable.



Comment 9 | Practical Skills (30)

Practical Observations

The design works as expected with a small flaw. When the fan is activated, the motor starts, but due to a set delay it turns off momentarily and then starts again. Additionally, when the motor

turns off, the alert LED is supposed to blink for three cycles, but it turns on while the motor is still running. It would be better if the motor turned off first, followed by the alert LED activating before the system shuts down. The use of a relay to control the motor is well implemented, and the inclusion of a reset button is a positive and innovative addition to the design.

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PAGE 9

PAGE 10



Comment 10 | Cognitive & Intellectual (25)

It is essential to discuss the limitations of the design in more detail, particularly how it differs from industrial automation cooling systems. It is also necessary to include the challenges faced during the design process, which are explained in some parts of the report.



Comment 11 | Knowledge & Understanding(20)

The report should also discuss CCS C constructs, including the program structure, I/O definitions, control statements, I/O configuration, and functions used to provide a clearer understanding of how the program is structured.



Comment 12 | Transferable Skills (15)

The code should be included in the appendix. However, the code is well structured, and the inclusion of reset concepts and comments where necessary is appreciated.

PAGE 11



Comment 13 | Transferable Skills (15)

A good structure is maintained throughout the report. It could be improved further by adding a critical review of the design, details on the selection of the microcontroller, CCS C structures, and the cooling system concept.

PAGE 12

DAFYDD ADAMS

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ENGAGEMENT WITH LITERATURE(10)

Research supports embedded automotive cooling logic and PIC-based simulation. Uses scholarly/technical sources and correct referencing.



Adequate sources; mostly descriptive; limited critical evaluation and linkage to design.

6

KNOWLEDGE & UNDERSTANDING(20)

Demonstrates knowledge of sequencing logic, timers/delays, I/O interfacing, LCD 4-bit mode, UART monitoring and real-world cooling workflow.



Satisfactory understanding; basic explanations provided but limited depth in some areas.

13

COGNITIVE & INTELLECTUAL (25)

Evaluates design approach and makes justified decisions using logical reasoning. Demonstrates structured thinking and reflective judgement.



Reasoning is basic and mostly descriptive; little justification of choices.

14

PRACTICAL SKILLS (30)

Implements and tests a PIC16F877A Proteus simulation meeting : switch sequencing, LED states, fan motor control, alert blink, LCD and UART messaging.

 Fully functional Proteus system meeting all ; correct sequencing, timing, LCD,UART messaging, motor control; well-tested and reliable.

27

TRANSFERABLE SKILLS (15)

Communicates work clearly and professionally through a structured report and well-documented code. Submits required files and evidence reliably.

 Well-structured report; clear communication; good code readability and presentation.

12