Lab 3 – Prototype Phase 1

ECE 298 – S2021

Lab Section:		Group:	Team 156

Part 1 – Pin Mapping

MCU Pin	Pin Mode	Functional Description
PA8	GPIO_Output	Toggles the outside green LED output
PA9	GPIO_Output	Toggles the inside green LED output
PA10	GPIO_Output	Toggles the red LED output
PA11	GPIO_Output	Toggles the yellow LED output
PC6	USART6_TX	Controls the LCD output for ASCII display
PB14	TIM1_CH2N	Motor driver input 1 with PWM
PB13	TIM1_CH1N	Motor driver input 2 with PWM
PB5	GPIO_EXTI5	START button that sends interrupt request to choose mode of operation
PB6	GPIO_EXTI6	ENTER button that sends interrupt request to select device options and parameters
PB7	GPIO_EXTI7	SCROLL button that sends interrupt request to scroll through available mode and parameter options
PC0	GPIO_EXTI0	Open limit switch to detect when the door is fully opened
PC1	GPIO_EXTI1	Close limit switch to detect when the door is fully closed
PC2	GPIO_EXTI2	Collision switch to detect when the door has collided against an object
PA12	GPIO_EXTI12	Reads the IDX output pulse from the motor encoder for speed control
PB8	GPIO_EXTI8	Reads Q1 signal as a trigger to toggle red LED on/off (i.e. flashing)
PC9	GPIO_Output	Output to send 10 microsecond signals to outside ultrasonic module
PC11	GPIO_Output	Output to send 10 microsecond signals to inside ultrasonic module
PC10	GPIO_EXTI10	Outside ultrasonic response output to be processed by the MCU
PB9	GPIO_EXTI9	Inside ultrasonic response output to be processed by the MCU

Part 2 – MCU Resources

MCU Resource	Functional Description
USART6	Communicates with the LCD screen module
TIM1	Generates PWM signal for DC motor driver inputs
TIM2	Generates 1MHz timer to be used for measuring length of output signal from ultrasonic modules to calculate distance to an object
GPIO	Only used as outputs to LEDs, and ultrasonic module
NVIC	Enables use of interrupts for push buttons, ultrasonic readings and motor encoder signals (Q1 and IDX)

Part 3 – Test Cases

Notable changes made to the circuit schematic in Lab 3 compared to the designs of Lab 1 and Lab 2:

- The back button was removed to simplify user inputs
- The up/down button was replaced by a scroll button to simplify user inputs
- Pull-down resistors are added to the push buttons to sink voltage when not pressed
- The LM016L LCD was replaced with the MILFORD-2x16-BKP
- The LCD interface was replaced with the internal UART tools provided by the MCU

Check the "Operational Overview.docx" document for how to run the system. Note that the LCD display requires waiting 500 ms before using it. As such, when running simulations, please always wait at least 500 ms before starting.

Currently, the door motor will continue rotating until one of the limit switches is pushed. Also, all MCU interfaces are the same as those from Lab2 (excluding the LCD display). As such, as calculated in Lab2, the current drawn from those pins are within the limits of the MCU.

Note that the Open Limit Switch, Close Limit Switch, and Collision Switches are interrupts that run in whatever state the current system is in. For the purposes of brevity, they are only tested in the LOCK mode in Tests 4, 5, 6. But it is possible to run those same tests in any other mode and they will still be fully functional. These tests were also run in the SETUP and RUN modes but not included in this report to avoid repetition.

Overall Schematic:

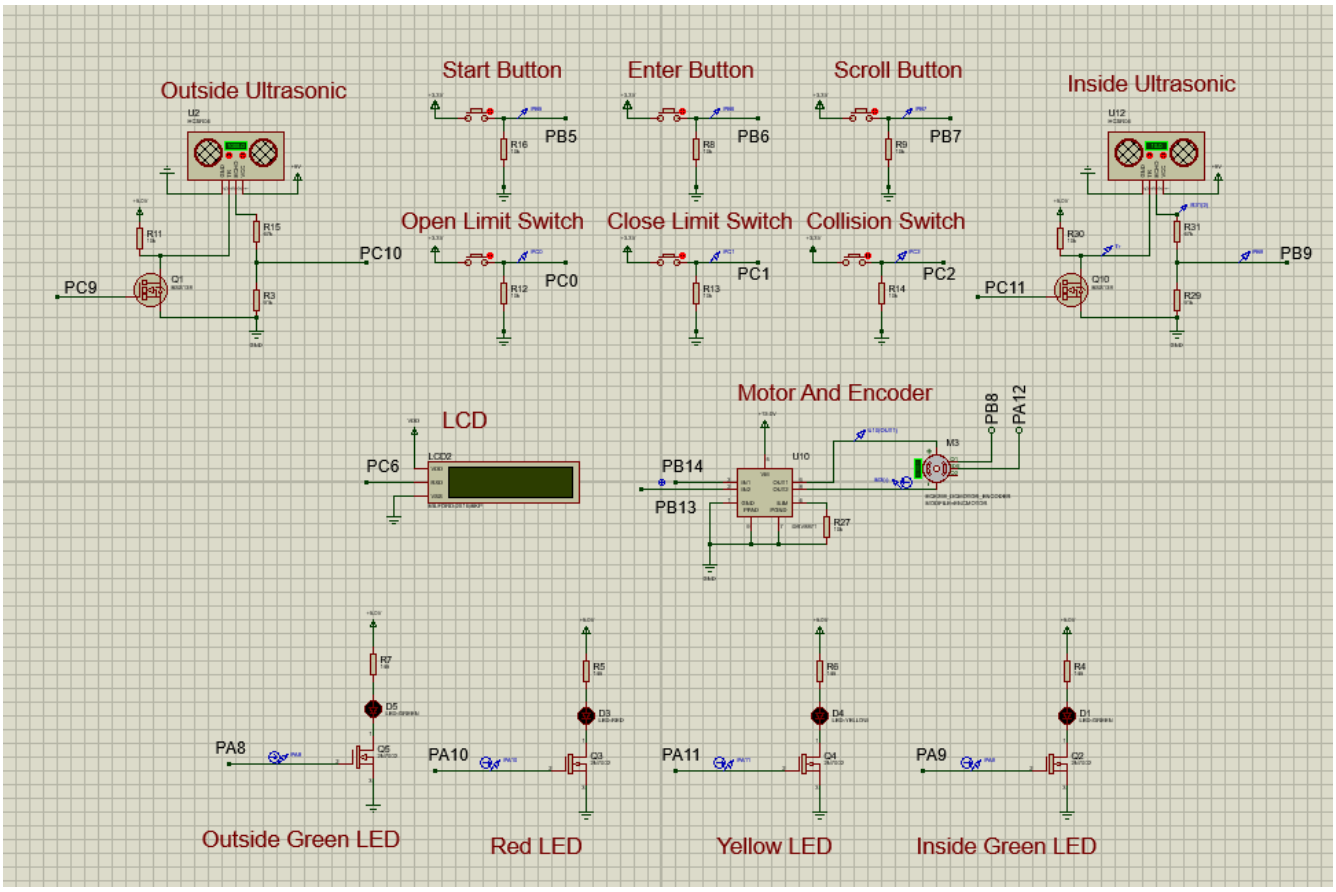

Fig. 0.1: Overall Schematic

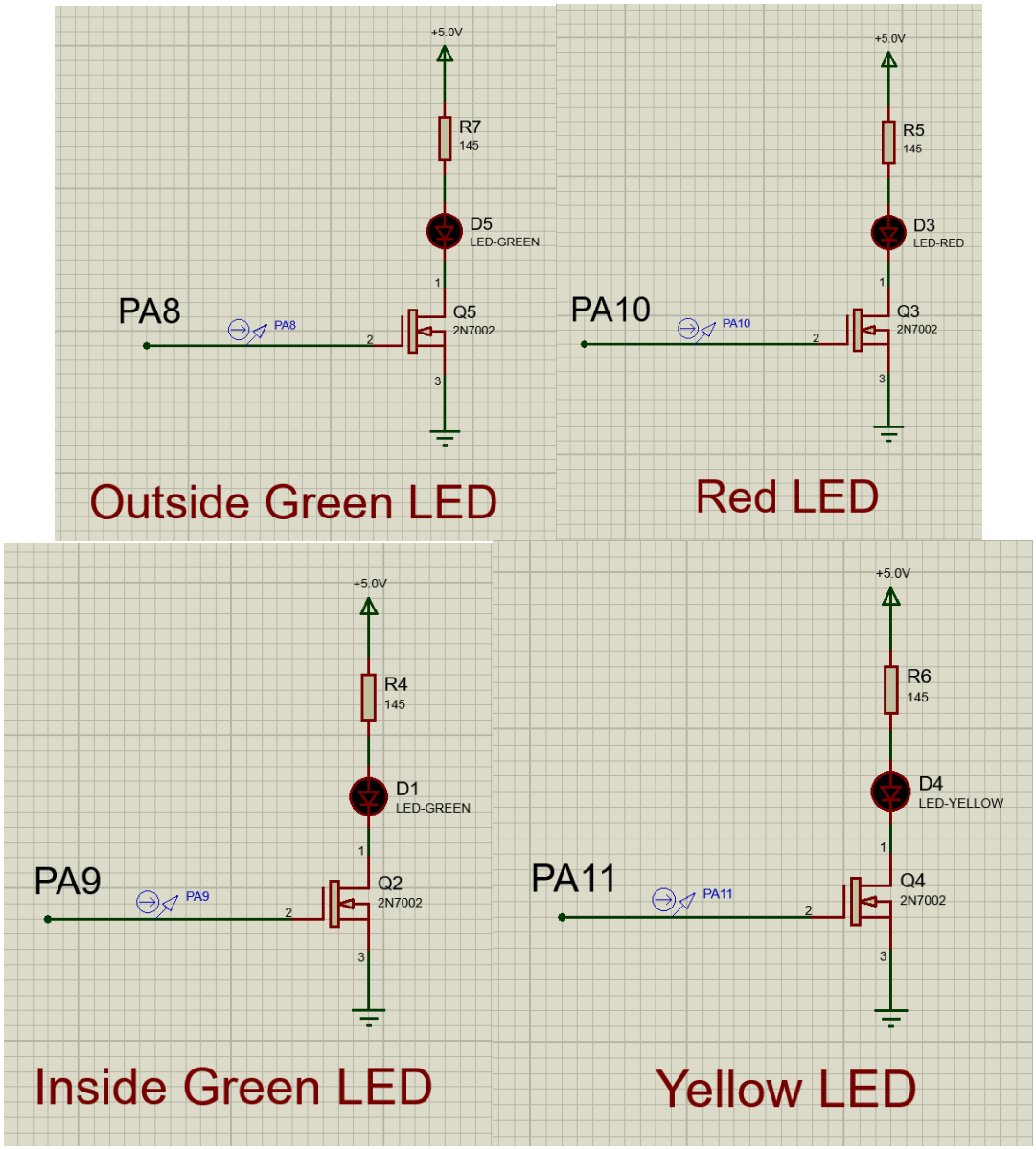

Fig. 0.2: LED Schematics

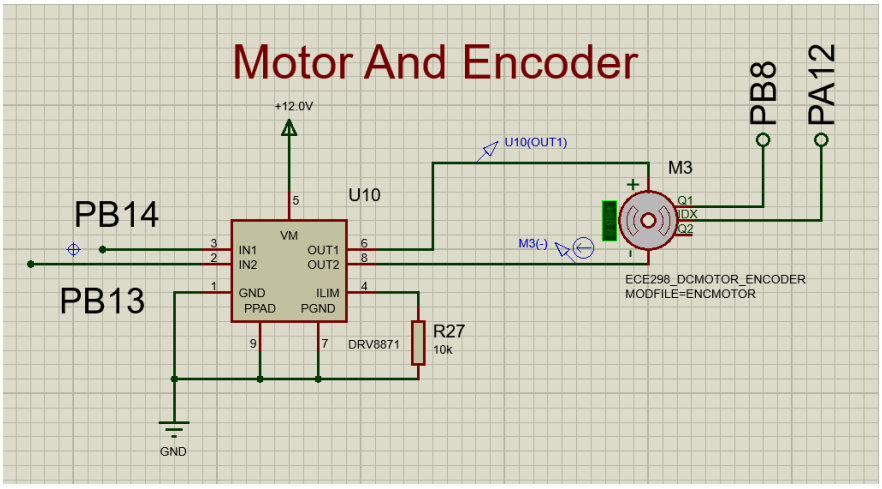

Fig. 0.3: Motor and encoder schematic

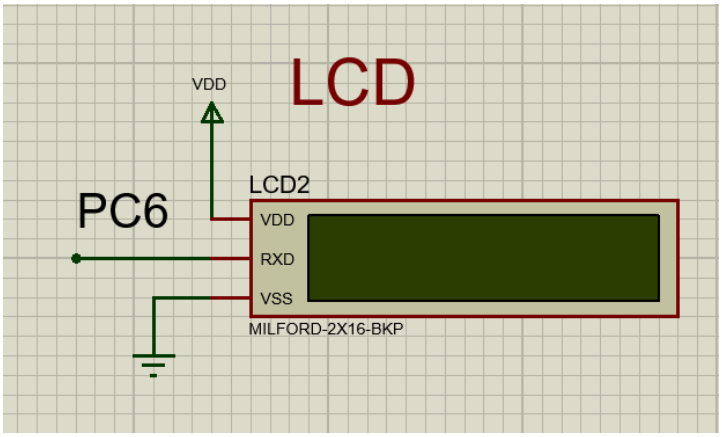

Fig. 0.4: LCD Schematic

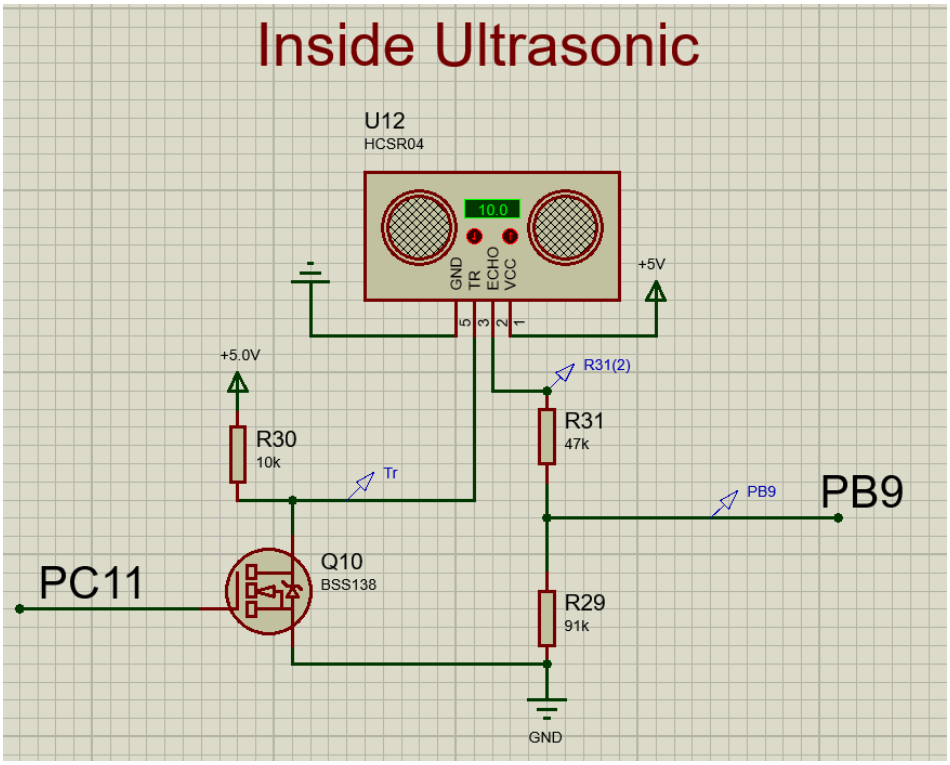

Fig. 0.5: Inside ultrasonic schematic

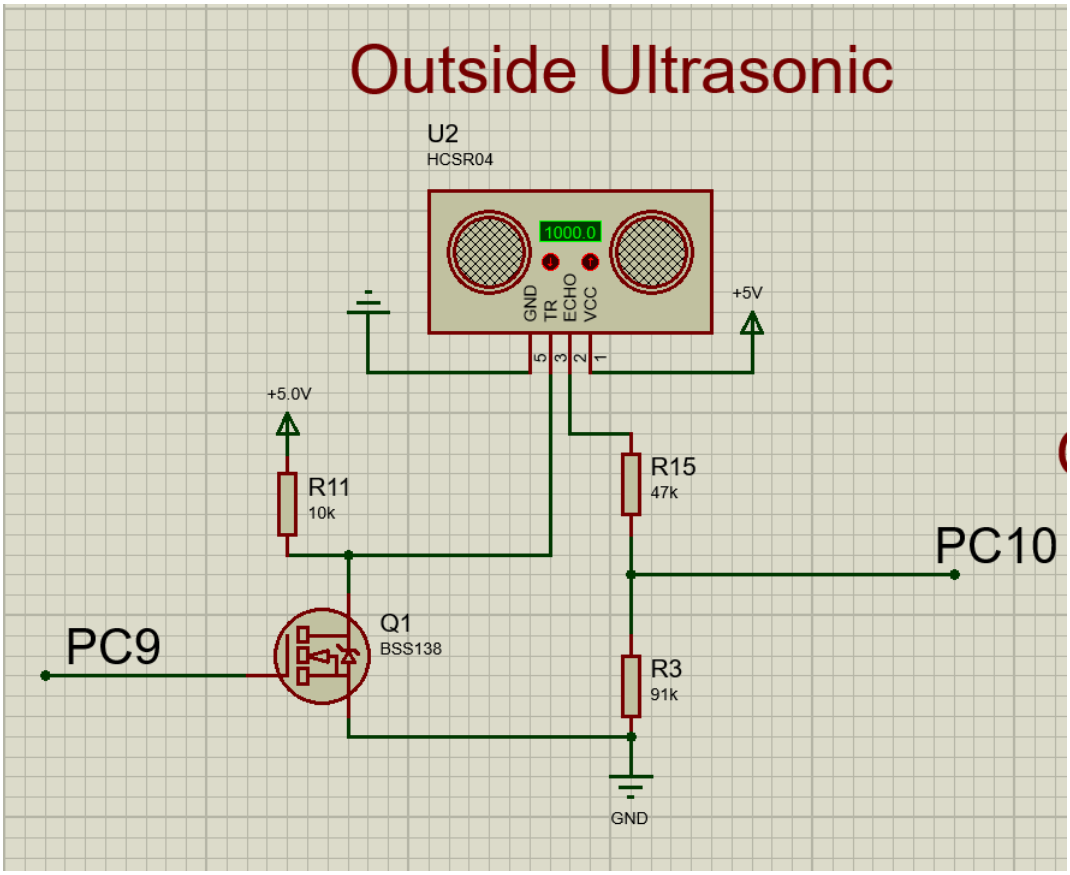

Fig. 0.6: Outside Ultrasonic Schematic

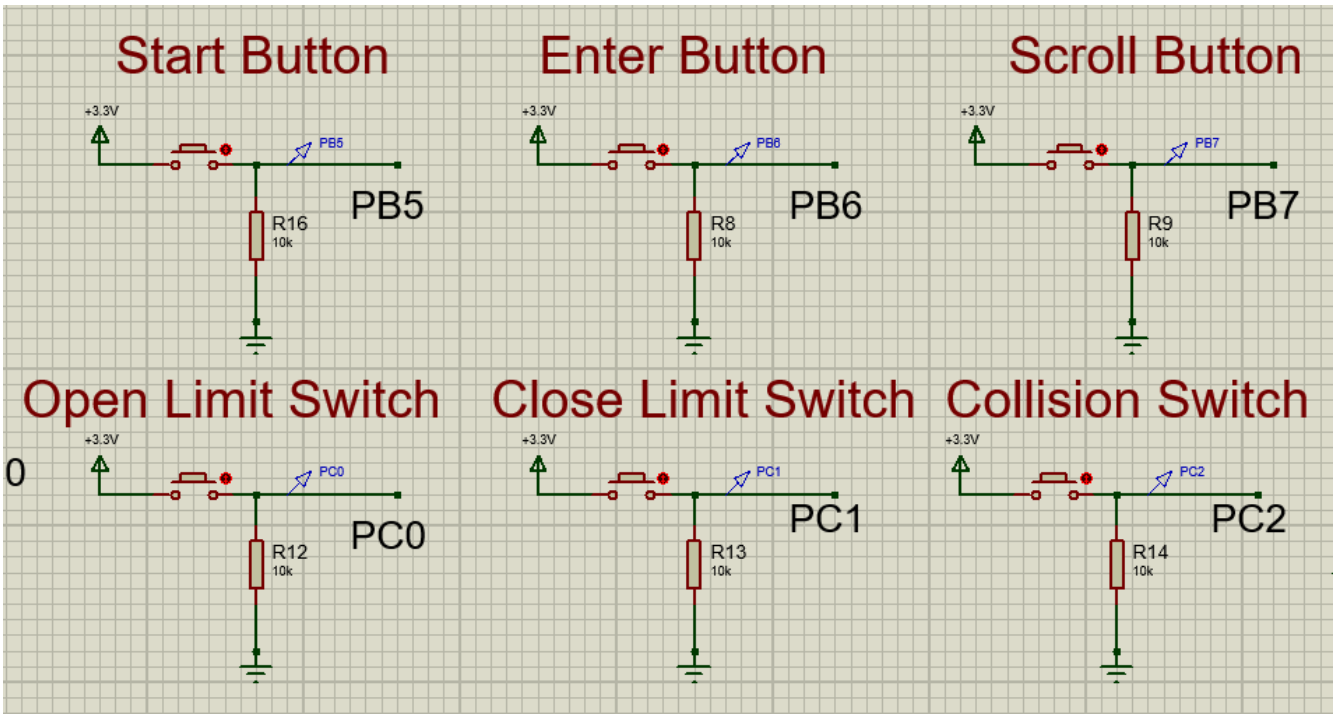

Fig. 0.7: Push Button schematics

Test 1: Changing Operating Modes

Requirement	User must be able to change the operating mode of the system at any point and select out of three options: RUN, SETUP, LOCK
Test Setup	1. Press START 2. Go through the instructions, scroll and select LOCK 3. Press START 4. Go through instructions, scroll and select SETUP 5. Press START 6. Go through instructions, scroll and select RUN
Expected Outcome	1. START button displays instructions on LCD 2. Selecting LOCK enters LOCK mode and displays it on LCD 3. Selecting SETUP enters SETUP mode and displays it on LCD 4. Selecting RUN enters RUN mode and displays it on LCD
Operational	Yes
What's Not Working	N/A

Schematics and Simulations

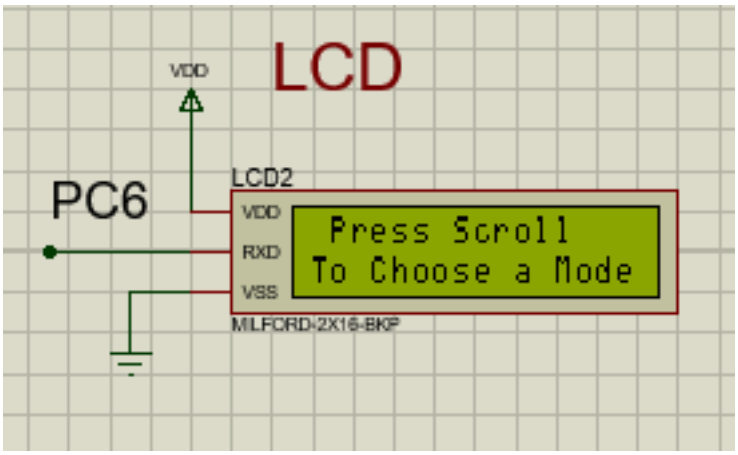

Fig. 1.1: Initial Main Menu

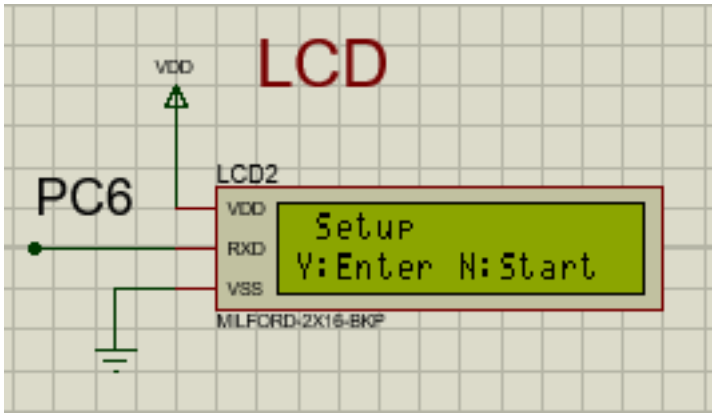

Fig. 1.2: First Option for Operational Mode (Setup)

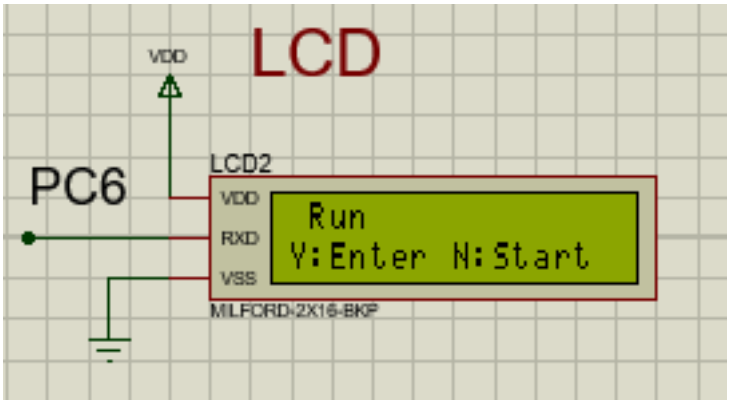

Fig. 1.3: Second Option for Operation Mode (Run)

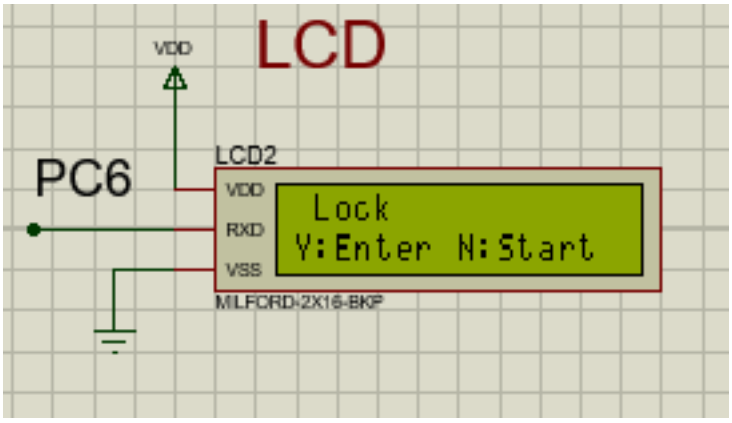

Fig. 1.4: Third Option for Operation Mode (Lock)

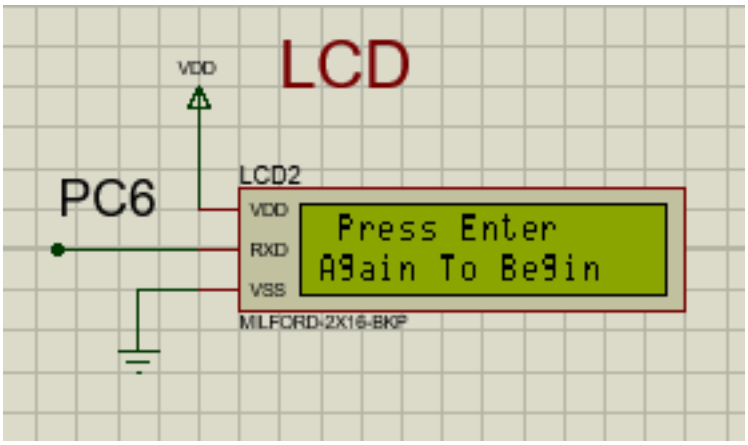

Fig. 1.5: Next Screen After Selecting an Operation Mode

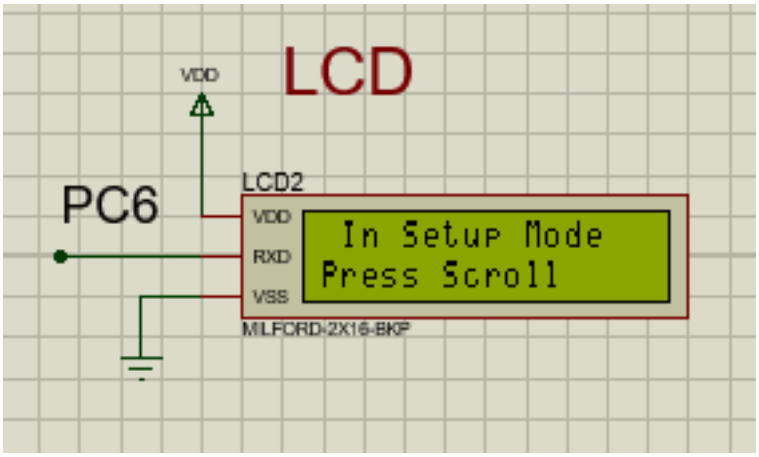

Fig. 1.6: Selecting the Setup Mode

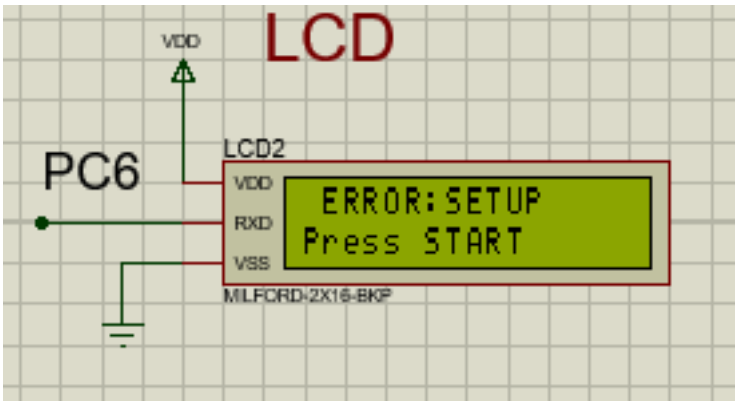

Fig. 1.7a: Error Message in Run Mode Since Parameters Haven't Been Setup

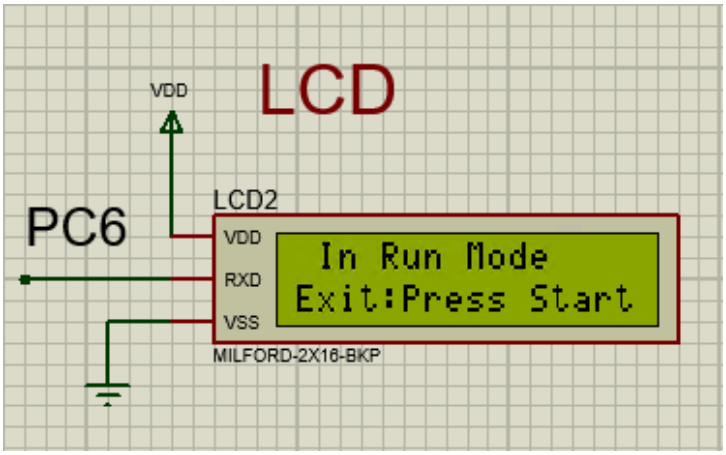

Fig. 1.7b: Selecting the Run Mode After Parameters Have Already Been Setup

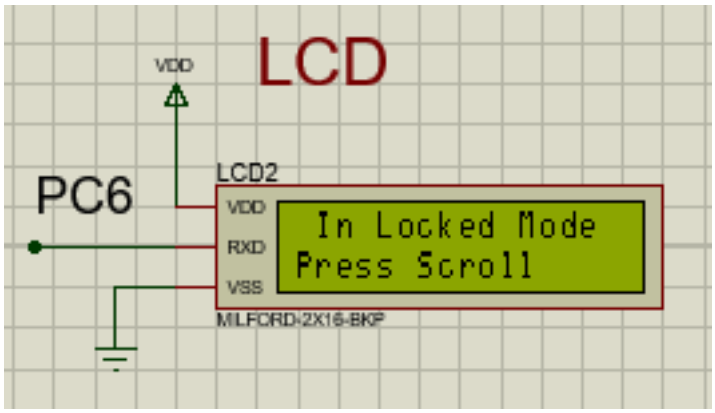

Fig. 18: Selecting the Lock Mode

Test 2: Locked Mode (Open)

Requirement	When selecting LOCK mode, the user must be able to choose the OPEN option to lock the system in an opened door position.
Test Setup	1. Press START 2. Go through the instructions, scroll, and select LOCK 3. Press START 4. Go through the instructions, scroll, and select OPEN option
Expected Outcome	1. The LCD displays instructions on selecting the LOCK mode operation 2. When entering the OPEN LOCK mode the motor begins to rotate with a negative RPM and the RED LED begins to flash
Operational	Yes
What's Not Working	N/A

Schematics and Simulations

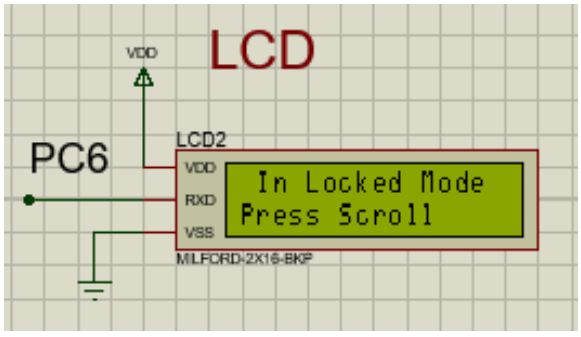

Fig. 2.1: First Entering the Lock Mode

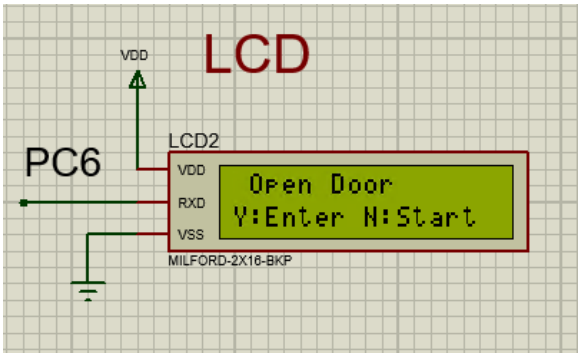

Fig. 2.2: Open Door Option in the Lock Mode

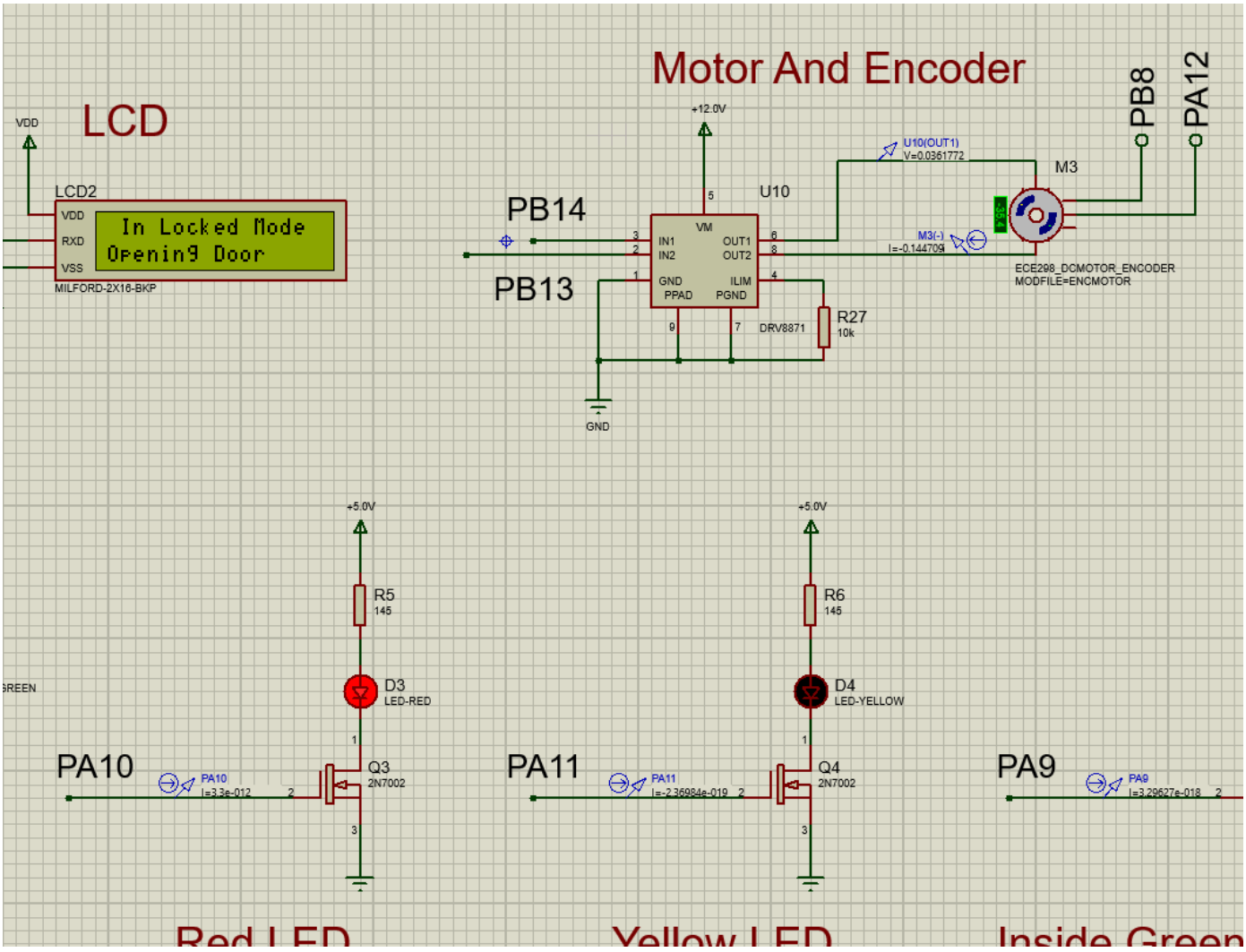

Fig 2.3: Operating in the Lock Mode with Motor Rotating (-ve RPM) and RED LED Flashing

Test 3: Locked Mode (Close)

Requirement	When selecting LOCK mode, the user must be able to choose the CLOSE option to lock the system in a closed door position.
Test Setup	1. Press START

	2. Go through the instructions, scroll, and select LOCK 3. Press START 4. Go through the instructions, scroll, and select CLOSE option
Expected Outcome	1. The LCD displays instructions on selecting the LOCK mode operation 2. When entering the CLOSE LOCK mode the motor begins to rotate with a positive RPM and the RED LED begins to flash
Operational	Yes
What's Not Working	N/A

Schematics and Simulations

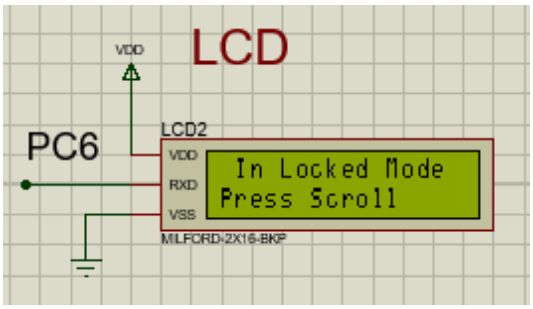

Fig. 3.1: First Entering the Lock Mode

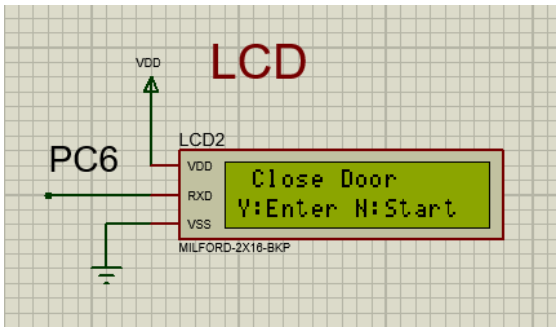

Fig. 3.2: Close Door Option in the Lock Mode

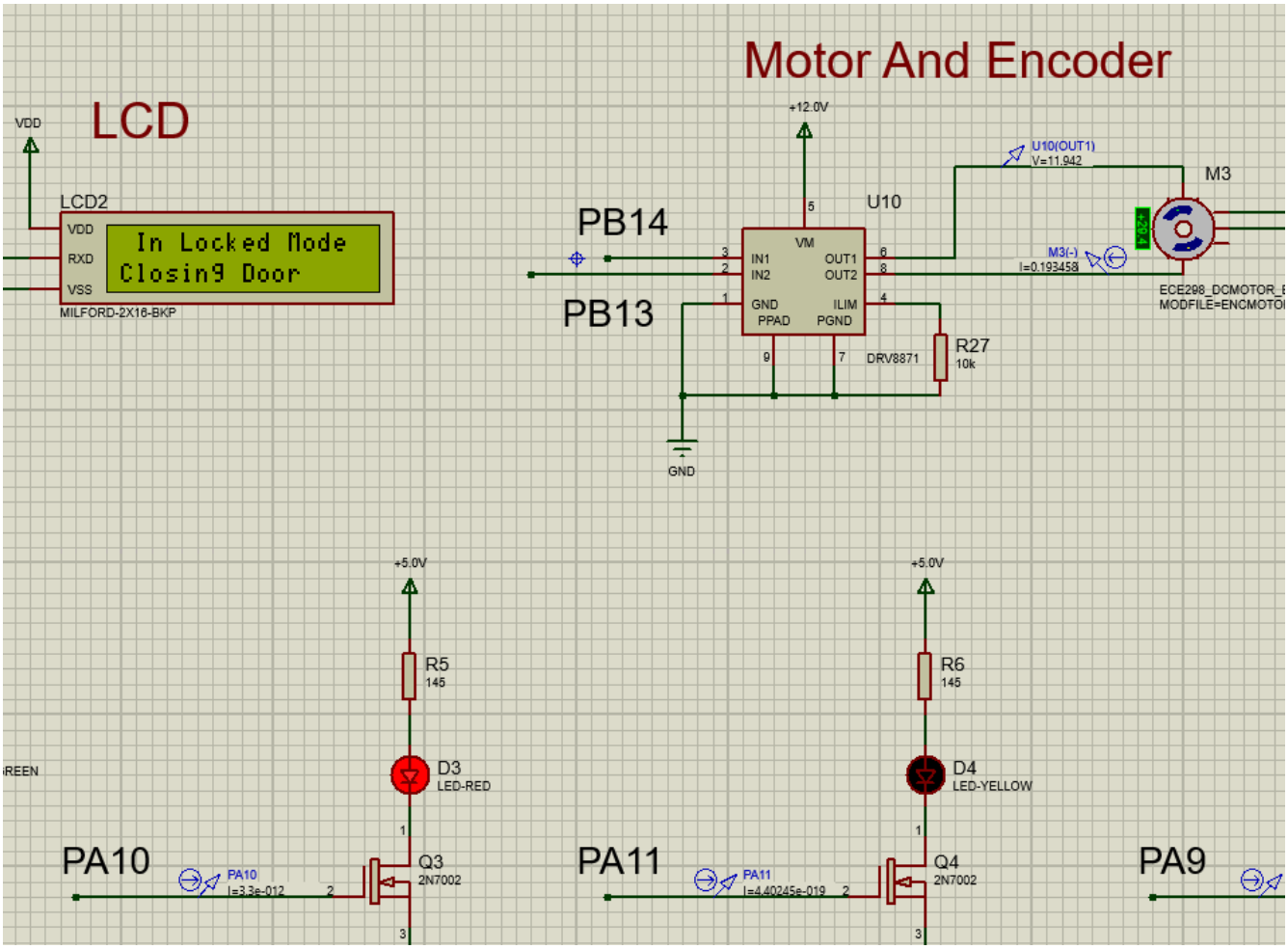

Fig 3.3: Operating in the Lock Mode with Motor Rotating (-ve RPM) and RED LED Flashing

Test 4: Open Limit Switch

Requirement	When the open limit switch has been hit, the system must signal to the motor that the door is fully opened, and thus the motor must ramp down and stop running.
Test Setup	1. Press START 2. Go through the instructions, scroll, and select LOCK 3. Press START 4. Go through the instructions, scroll, and select OPEN option 5. Wait 5 seconds 6. Press OPEN LIMIT SWITCH button
Expected Outcome	1. When the OPEN LIMIT SWITCH button has been pressed, the motor begins to ramp down and eventually stops rotating
Operational	Yes
What's Not Working	N/A

Schematics and Simulations

Fig. 4.1: Graph of Motor on Hitting Open Limit and Ramping Down to Stop

Test 5: Close Limit Switch

Requirement	When the close limit switch has been hit, the system must signal to the motor that the door is fully closed, and thus the motor must ramp down and stop running.
Test Setup	1. Press START 2. Go through the instructions, scroll, and select LOCK 3. Press START 4. Go through the instructions, scroll, and select CLOSE option 5. Wait 5 seconds 6. Press CLOSE LIMIT SWITCH button
Expected Outcome	1. When the CLOSE LIMIT SWITCH button has been pressed, the motor begins to ramp down and eventually stops rotating
Operational	Yes
What's Not Working	N/A

Schematics and Simulations

Fig. 5.1: Graph of Motor on Hitting Close Limit and Ramping Down to Stop

Test 6: Collision Switch

Requirement	When the collision switch has been hit, the YELLOW LED should start flashing and the motor should ramp down and stop so long as the push button has been pressed. When the button is released, the motor should start rotating with a positive RPM at 0.5 ft/sec until the door is closed.
Test Setup	1. Press START 2. Go through the instructions, scroll, and select LOCK 3. Press START 4. Go through the instructions, scroll, and select OPEN option 5. Wait 5 seconds 6. Press and hold the COLLISION SWITCH button 7. Wait 5 seconds 8. Release the COLLISION SWITCH button
Expected Outcome	1. When the COLLISION SWITCH button has been pressed and held down, the YELLOW LED should flash while the button is held down and the motor should ramp down to an eventual stop 2. When the COLLISION SWITCH button has been released, the YELLOW LED should stop flashing and the motor should begin rotating at a maximum of 45 RPM (converts to a maximum of 0.5 ft/sec)

Operational	Yes
What's Not Working	N/A

Schematics and Simulations

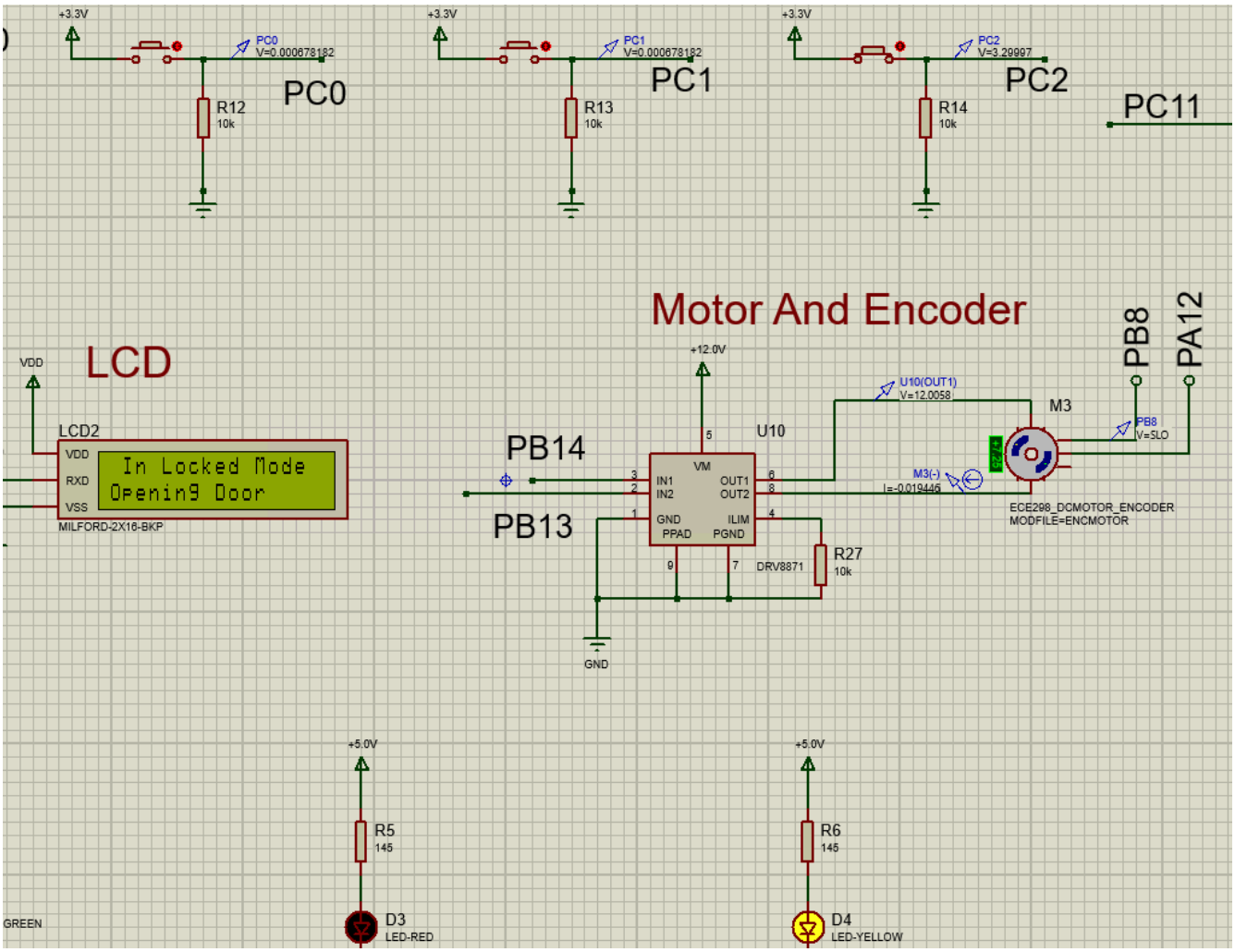

Fig. 6.1: Collision Switch Pressed Down Causing YELLOW LED to flash and Motor to Ramp Down

Fig. 6.2: Collision Switch Graph on Collision & Restart

Test 7: Setup Mode (Selecting Parameters P1, P2, P3, P4, P5)

Requirement	User must be able to select values for each parameter (P1, P2, P3, P4, P5) so the system can operate using the selected values.
Test Setup	1. Press START 2. Go through the instructions, scroll, and select SETUP 3. Go through the instructions, scroll, and select any value for P1 4. Repeat step 3 for P2, P3, P4, and P5
Expected Outcome	1. The LCD displays the appropriate instructions for each step of the setup mode 2. The system records the value of the parameter
Operational	Yes
What's Not Working	N/A

Schematics and Simulations

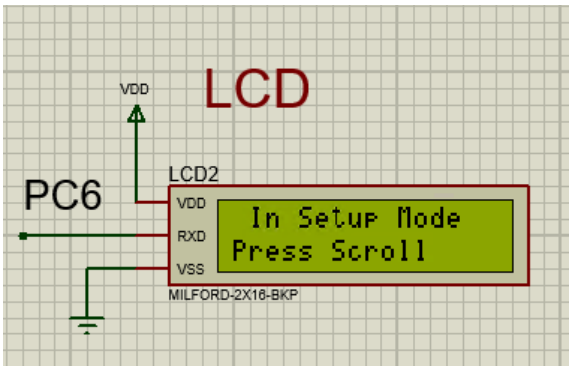

Fig. 7.1: In the Setup Mode

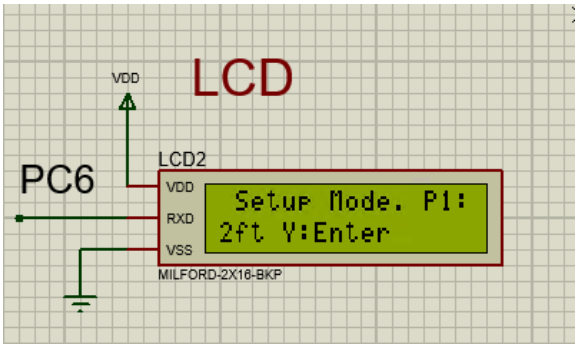

Fig. 7.2: Option 1 (2ft) for Parameter P1

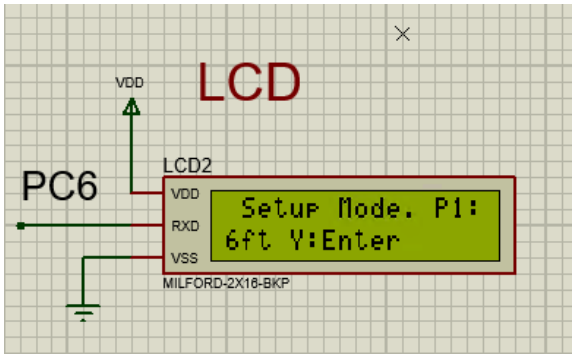

Fig. 7.3: Option 3 (6ft) for Parameter P2

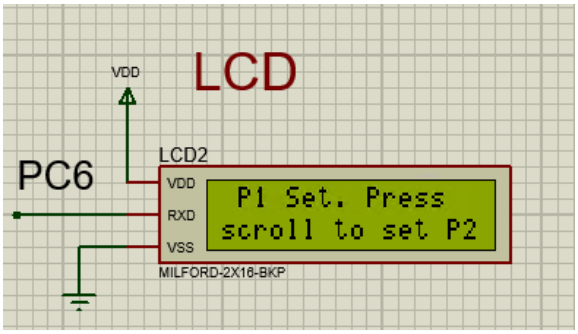

Fig. 7.4: Screen Display After Selecting Parameter P1

Test 8: Run Mode (Normal Operation)

Requirement	User must be able to run the system properly as described in the Lab project description after having properly gone through the SETUP mode.
Test Setup	1. Set the outside ultrasonic module to have an object at 1000 cm 2. Set the inside ultrasonic module to have an object at 2 cm 3. Press START 4. Go through the instructions, scroll, and select SETUP 5. Go through the instructions, scroll, and select the following values: ● P1 = 2 ft ● P2 = 8 ft ● P3 = 20 seconds ● P4, P5 = any value 6. Press START 7. Go through the instructions, scroll, and select RUN 8. Enter the RUN mode 9. Wait 2 seconds then press OPEN LIMIT SWITCH
Expected Outcome	1. LCD Displays that the system is running when entering RUN mode 2. The inside GREEN LED should be on and the outside GREEN LED should be off when running 3. The motor should open (negative RPM) when entering the RUN mode (since there is an object within the boundary) 4. The motor should stop once the door is fully opened (OPEN LIMIT SWITCH pressed) 5. The system should wait 20 seconds before closing the door again
Operational	Expected outcomes 1-4 are working
What's Not Working	The system doesn't wait 20 seconds and then close the door again because the ultrasonic module is set in the beginning and when the proteus simulation is running, it's not possible to change the module's properties. As a result, the software always detects that there is an object detected by the inside ultrasonic module. Because of this, the inside GREEN LED never turns off, and the door will never close. To correct this, there needs to be another way to simulate an object being detected by the ultrasonic module. A possible solution is to instead have a digital pulse input to simulate the ultrasonic module, where the pulse is so that the ultrasonic detects an object within the distance once every 10 seconds or so. Thus, the software is correct, but the hardware is not.

Schematics and Simulations

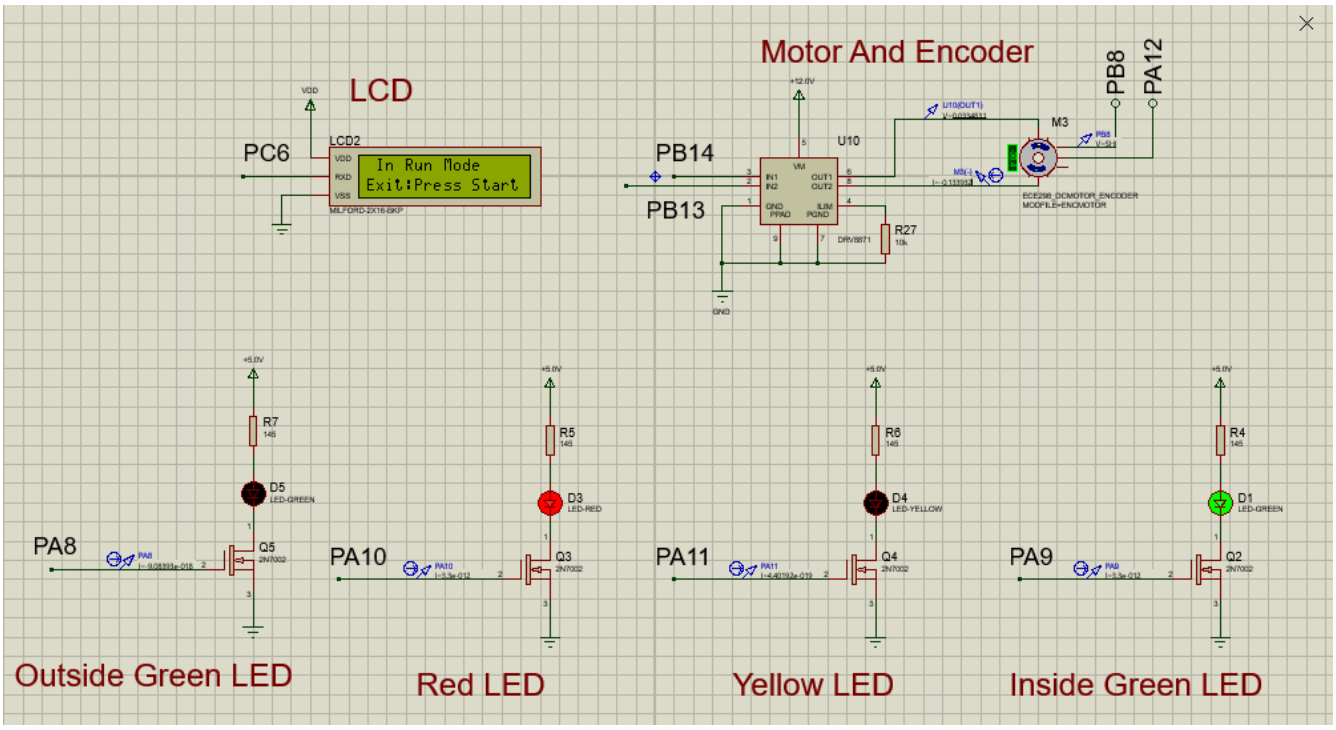

Fig. 8.1: Run Mode with Object in Boundary Detected by Inside Ultrasonic Module

Test 9: Run Mode (Different Ramp-up/Ramp-down Speed Constant)

Requirement	User must be able to change the ramp-up speed to change the speed of the motor.
Test Setup	1. Set the outside ultrasonic module to have an object at 500 cm 2. Set the inside ultrasonic module to have an object at 2 cm 3. Press START 4. Go through the instructions, scroll, and select SETUP 5. Go through the instructions, scroll, and select the following values: • P1 = 2 ft • P2 = 8 ft • P3 = any value • P4 = Level 4 • P5 = Level 1 6. Press START 7. Go through the instructions, scroll, and select RUN 8. Enter the RUN mode 9. Wait 2 seconds then press OPEN LIMIT SWITCH
Expected Outcome	1. LCD Displays that the system is running when entering RUN mode 2. The inside GREEN LED should be on and the outside GREEN LED should be off when running 3. The motor should open with a faster ramp-up speed (more negative RPM) when entering the RUN mode (since there is an object within the boundary) 4. Once the OPEN LIMIT SWITCH button has been pressed, the motor should ramp down with a lower speed

Operational	Expected outcomes 1-3 are working.
What's Not Working	The software as implemented does not have a way to properly setup the ramp-down to correlate to the set parameter P5. This is because the current way the motor_off helper function is implemented merely sets both channels to the motor driver inputs to 0 volts. As such, the ramp-down constant, though settable in SETUP mode is technically unchangeable. This makes the software incorrect, but the hardware correct.

Schematics and Simulations

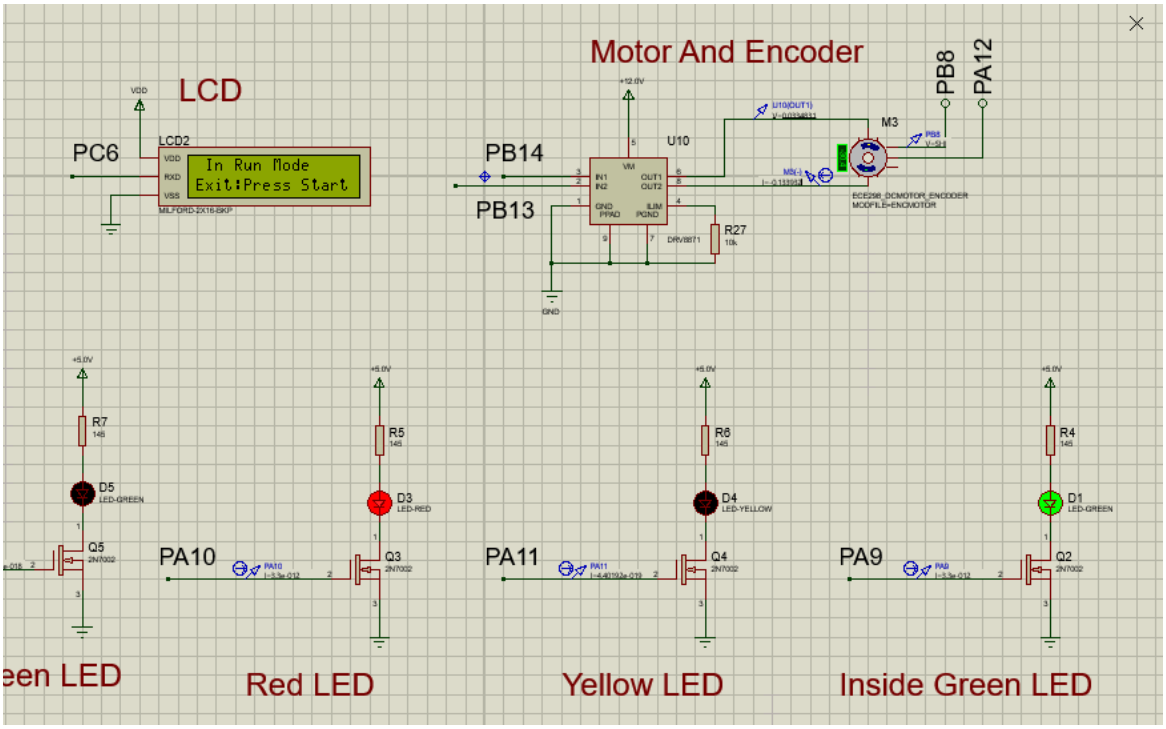

Fig. 9.1: Run Mode with Object in Boundary Detected by Inside Ultrasonic Module

Fig. 9.3: Motor Ramping Up and Ramping Down

```
1085 }
1086
1087 /* @brief Helper function to turn off the motor
1088  */
1089
1090 void motor_off() {
1091
1092     TIM1->CCR1 = 0;
1093     TIM1->CCR2 = 0;
1094
1095 }
1096
```

Fig. 9.2: Ramp-down Incorrect Software Section