Lab B1 – Feasibility Model Phase 1

ECE 298 – F2021

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Part 1 – Project Design Requirements

1. **Functional Requirements**
   A. The home security system would need a Comm Terminal that is responsible for controlling the overall systems as well as any setting within the system.
   B. The home security system must be able to monitor the access of 4 windows and 2 doors. Access can be gained by entering a four-digit passcode using an external keypad. The passcode can be set using the Comm Terminal.
   C. The home security system should also be able to detect the approach of any person to the front and/or back door and respond by turning on a light at the corresponding location.
   D. The home security system should be able to set the mode of the system to either ARMED or DISARMED using the Comm Terminal. Under the ARMED mode, any opening of a window/door without the corrected passcode will activate the ALARM mode. When ALARM is triggered, an audible alarm should be turned on after a short delay.
2. **Non-functional Requirements**
   A. The display panel for the home security system should be clear and easy to use.
   B. The home security system should be energy efficient to extend the battery life of the system.
3. **Constraint Requirements**
   A. The home security system should fit within a 6-inch(W) x 8-inch(L) x 2-inch(H) frame.

Part 2 – Project Considerations for I/O

Project Sensors and User Inputs

The system would need two types of sensors. A distance sensor (HCSR04) is placed on each door for monitoring the approach of any person. To communicate to the MCU, the sensor must first use an analog to signal converter to transform the analog output from the sensor to a digital value that can be read by the MCU. An op-amp should also be placed between the sensor and the MCU to transform the output voltage from the sensor to a voltage that is compatible with the MCU. An open and close sensor(SWITCH) should also be placed on each of the windows and doors to monitor the closing and opening of it. An analog to digital converter may be needed to convert the signal output from the switch to a digital signal that can be read by the MCU.

The system would also require a keypad(KEYPAD-PHONE) for entering the passcode. The keypad would need to connect to a signal converter before connecting to the MCU to translate the output signal from the keypad to a digital signal that can be read and understood by the MCU.

Project Actuators and User Outputs

There will be two relays (en-g5ca) used in the system. One is the AUDIBLE ALARM speaker to sound the alarm, the other is external lighting to detect persons approaching either of the entrances. They are all isolated from any other electronic circuitry.

LCD(MILFORD_2x16) will be used as output. When the system is in the RUN mode, the LCD will show the system sensor status. When the system is in the SETUP mode, the LCD will indicate the Mode, Parameter Name and Parameter Value.

There will be a total of four LEDs used in the system for sensor status LEDs, and a system alarm LED. Three of them are used to indicate ARMED, DISARMED, and ALARM status. They will be labeled as LED-ARMED, LED-DISARMED, LED-ALARM. In addition, the LED-ALARM will always be RED. The system will also have a FLASHING RED LED to indicate the SYSTEM ALARM. We will use GREEN color(LTL-5234) to indicate ARMED, YELLOW color(LTL1CHKYK)to indicate DISARMED, and RED color(PM3XXX) to indicate ALARM and SYSTEM ALARM.

The LEDs are each connected to a driving circuit with an OP AMP to amplify the voltage from the MCU to a voltage that is required by the LED to operate. The LCD is connected to the MCU via the serial interface. The actuators are connected to the MCU via an OPAMP to scale the voltages to be compatible with the MCU.

Project MCU Internal Resources

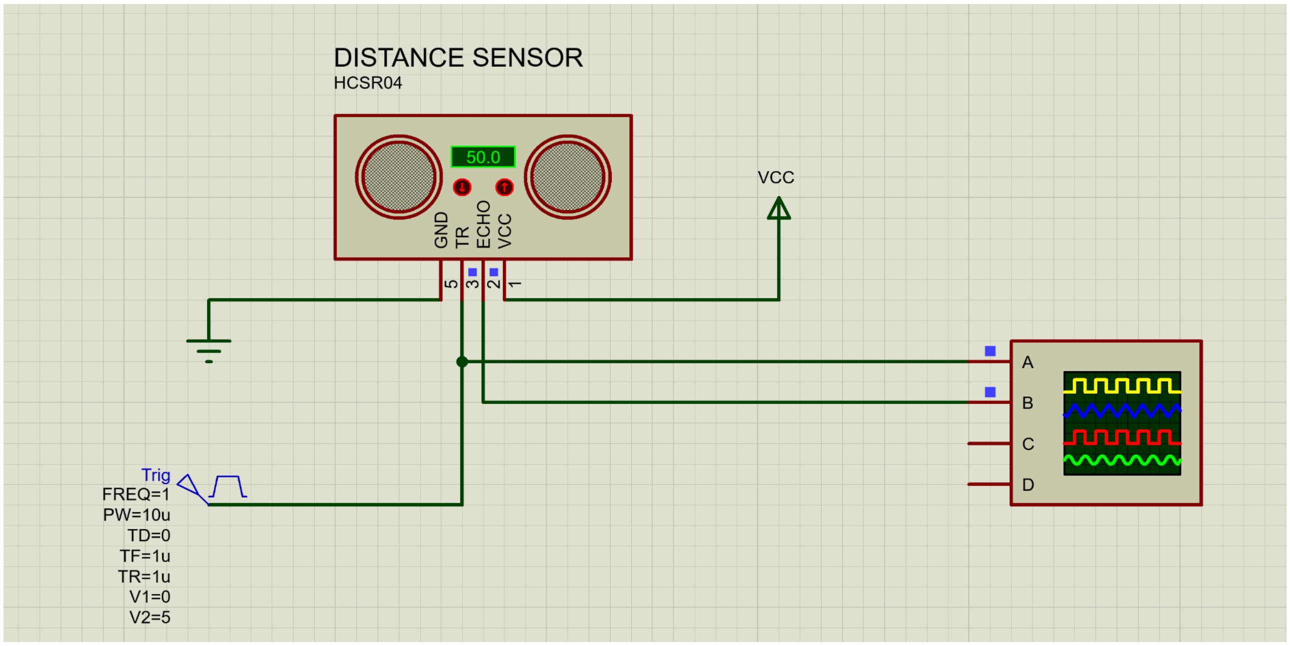
An analog to digital converter might be implemented within the MCU since there are many analog outputs from the devices that are connected to the MCU. Placing an ADC within the MCU will reduce both space and cost of the overall system. A GPIO would then be needed to interpret the digital signal that is converted by the ADC.

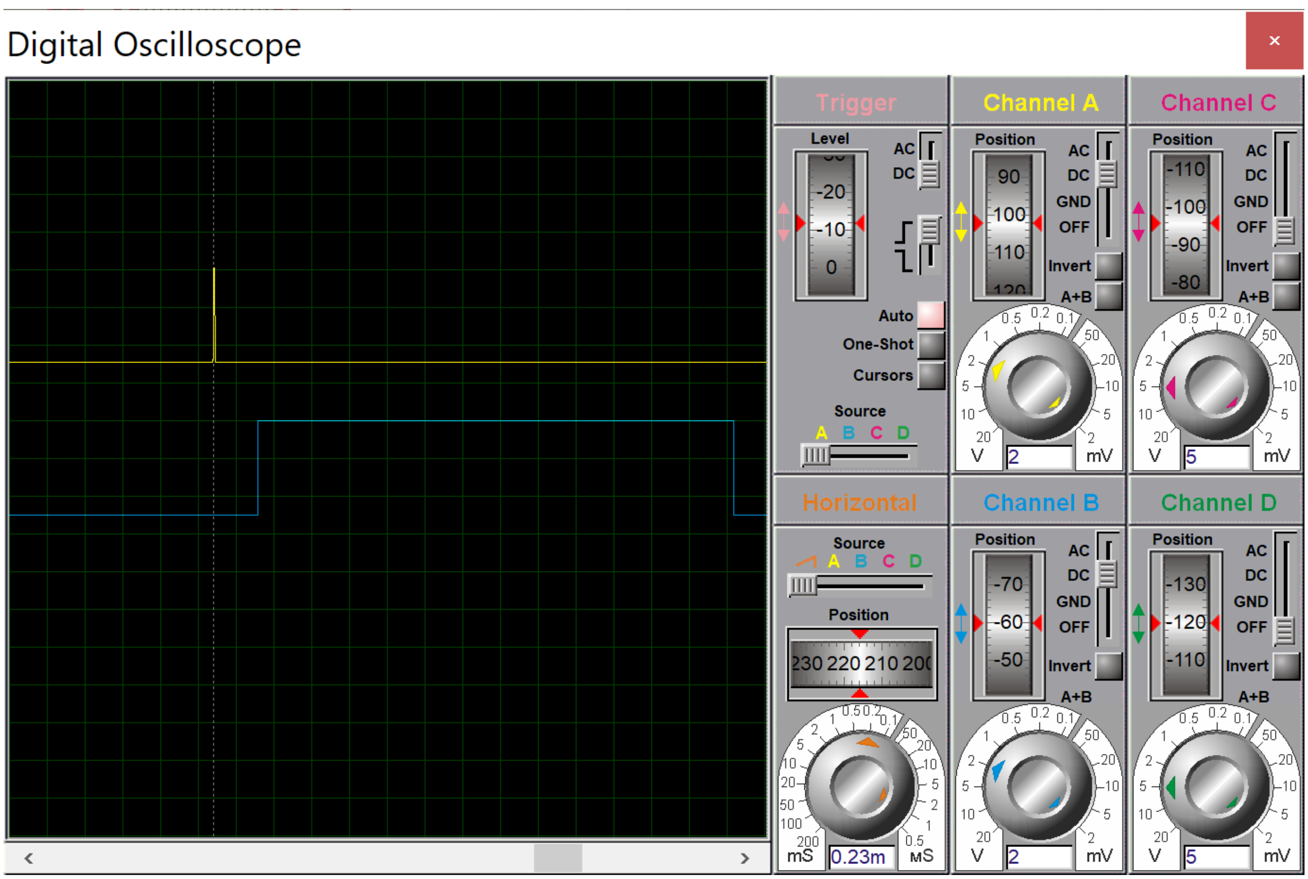
A timer should also be placed within the MCU together with an interrupt. The timer would be used for counting the alarm activation delay and the interrupt would be able to interrupt the timer when a correct passcode is entered before the countdown is finished.

The MCU would need to run software to determine the input signal from the keypad. The software should also be able to set the passcode as well as the state/mode of the home security system.

Part 3 – Device Testing Methodology

Device 1 – HCSR04 (Distance Sensor)





Methodology

For the distance sensor, we can observe the device's function by reading the feedback signal from the ECHO output of the device. Looking at the schematics above, a 10u sec pulse signal is sent into the sensor, and from the readings on the sensor we can see a distance of 50 is set, so the distance sensor should respond by sending a signal out through the ECHO port.

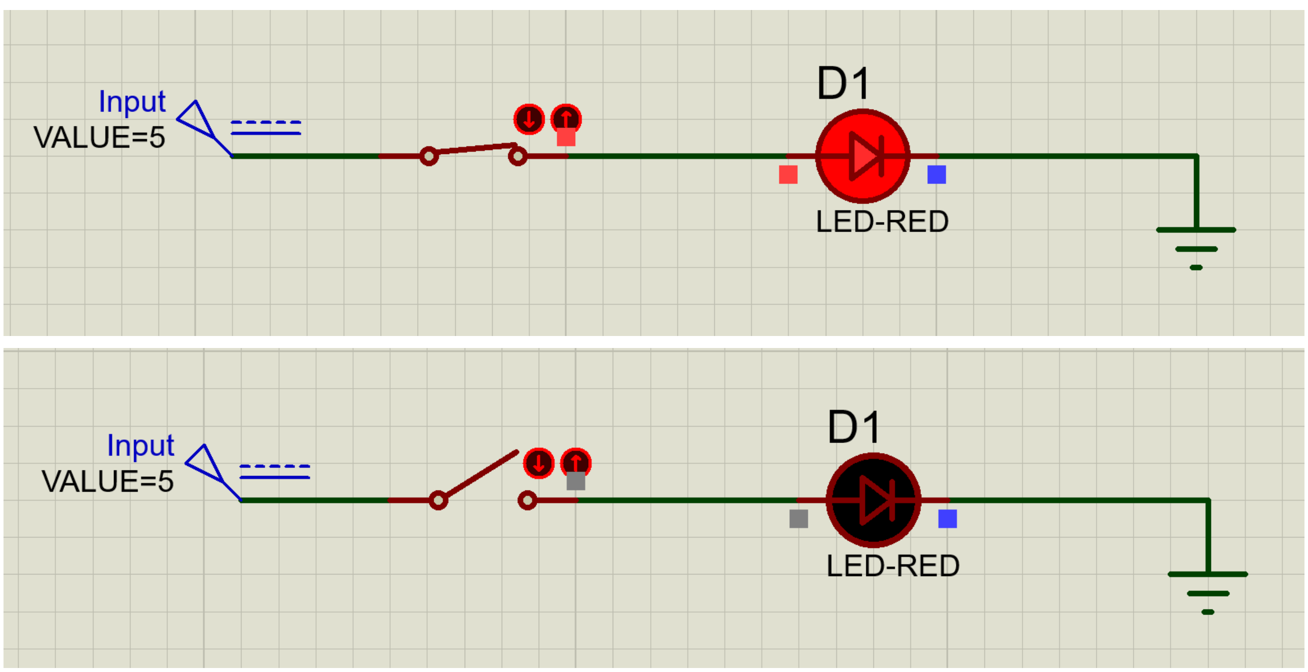
Verification

The expected behaviour can be confirmed using the digital oscilloscope, where Channel A represents the signal that is sent into the sensor, and Channel B represents the signal that the sensor sent back as a result.

Validation

The behaviour from the distance sensor satisfies the requirement to detect the approach of a person, and the output signal can be used to indicate the state of the sensor.

Device 2 – SWITCH (Open/Close Sensor)



Methodology

The switch is used to detect the closing and opening of a door/window. The State of the switch itself will represent the state of that door/window. When the switch is open, the circuit is not complete, therefore no voltage will go through. When the switch is closed, the circuit is complete and a voltage will travel through to the rest of the circuit.

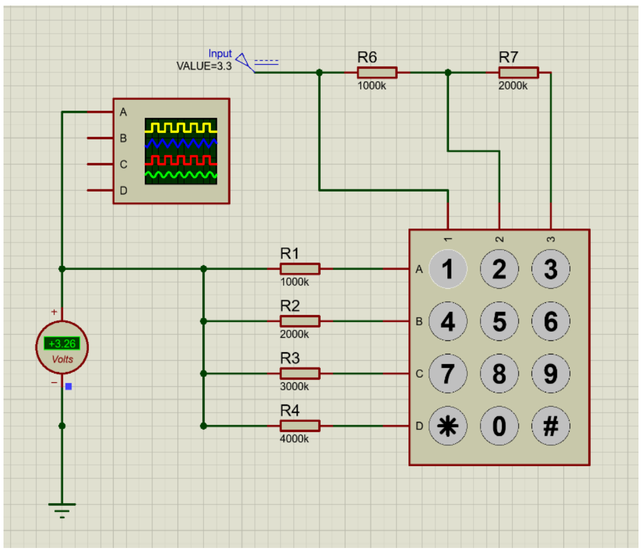
Verification

The above schematics demonstrate the switch in its two states, we can observe that when the switch is closed, the LED lights up, indicating that there is indeed a voltage going through the circuit. When the switch is open, the LED turns off, indicating that the connection has broken up and that there is no longer any voltage going through the circuit.

Validation

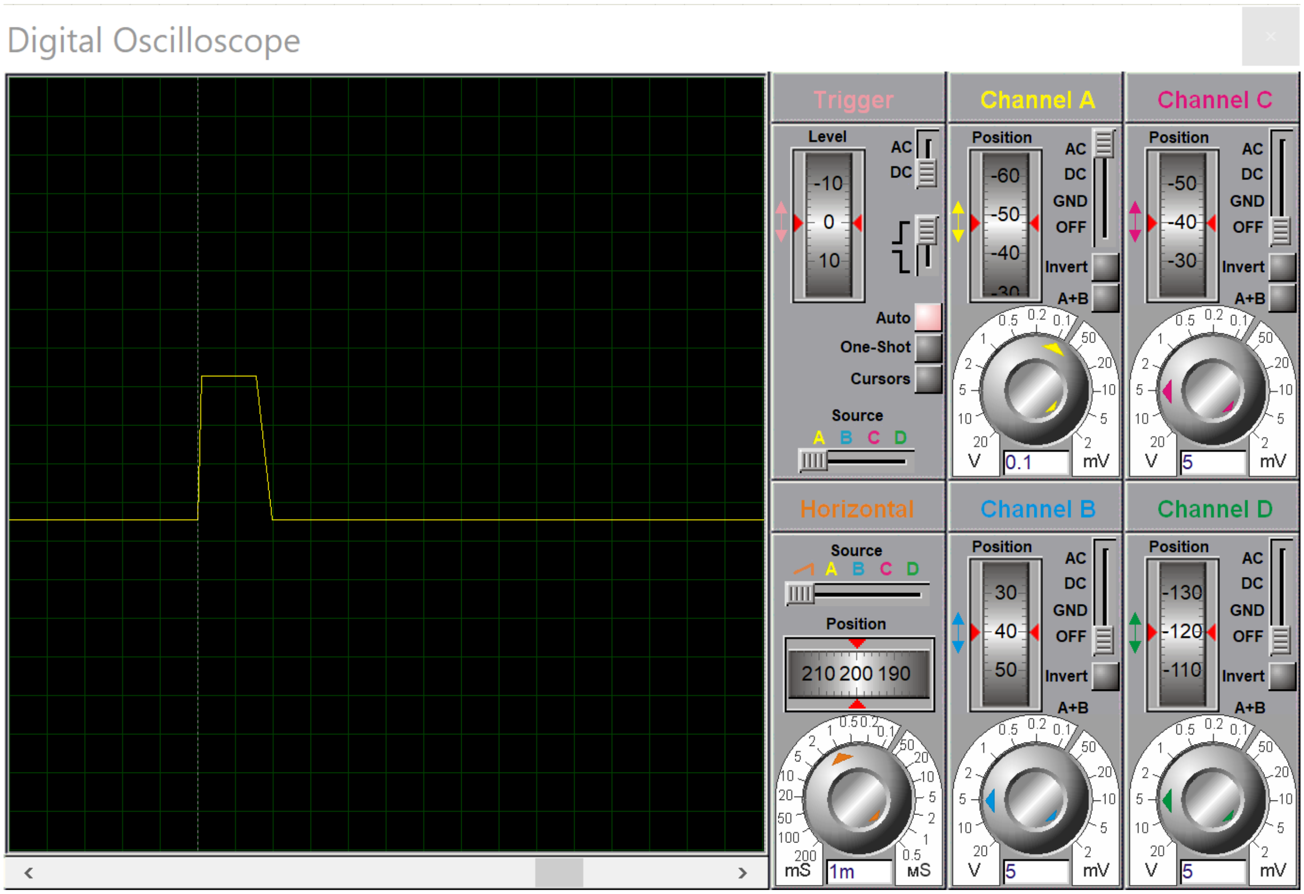
The switch satisfies the requirement of sensing the closing and opening of a door/window. We can easily observe the states by checking whether a voltage is sent in from that port or not.

Device 3 – KEYPAD-PHONE (Keypad)



The table shows the different voltages that is measured when different keys are pressed

3.26 V	3.21 V	3.14 V
3.22 V	3.18 V	3.11 V
3.19 V	3.15 V	3.09 V
3.17 V	3.13 V	3.07 V



Methodology

The keypad is connected to a different size resistor for each of its rows and columns, an input voltage is sent into the keypad from the columns ports, and the output is captured from the rows ports. So that whenever a key is pressed, depending on the resistor that it is connected to for that specific row and column, a different voltage value would be outputted. When no button is being pressed, the default voltage is 2.89 V.

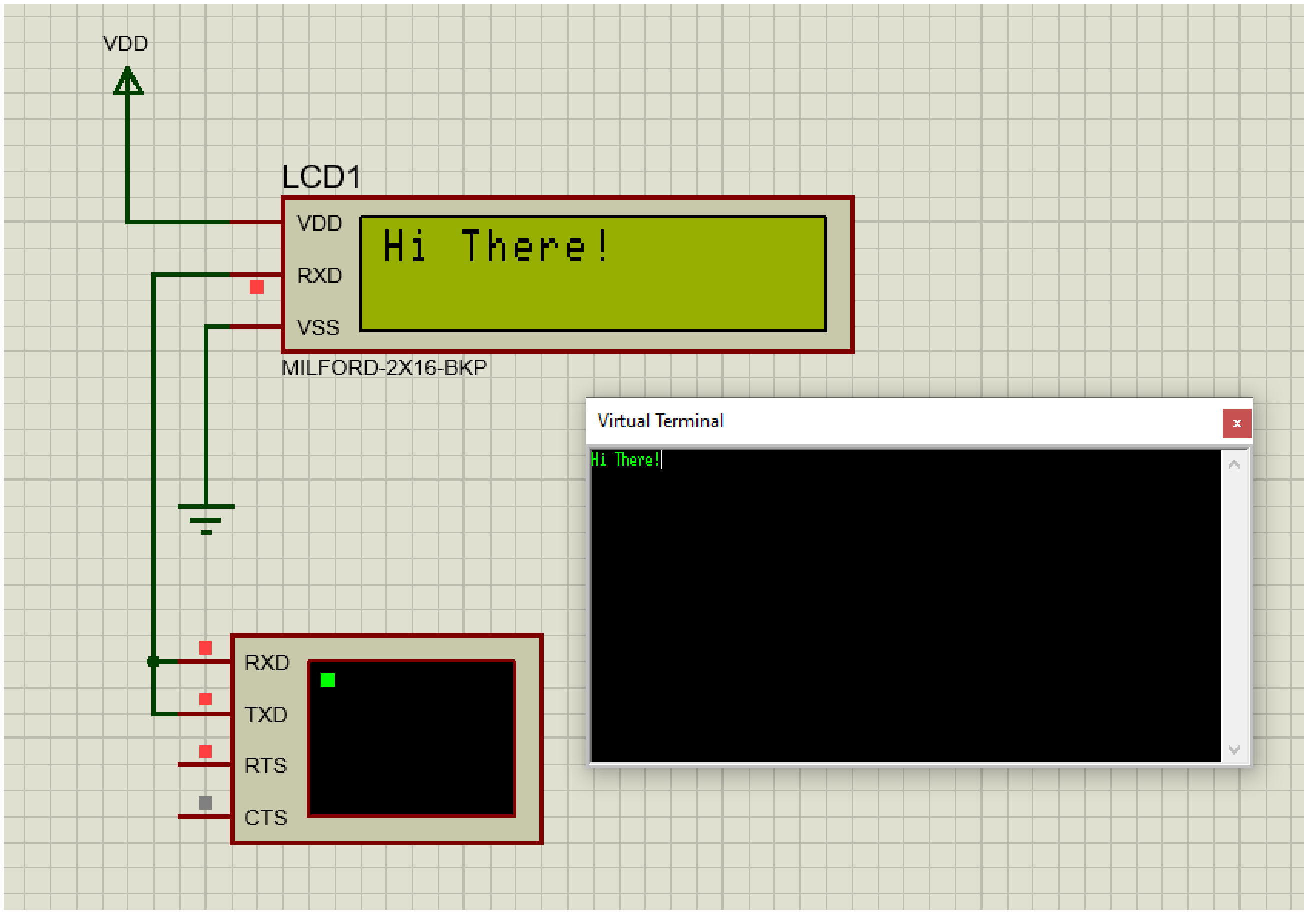
Verification

From the schematics above, we can observe that when button 1 is pressed, the voltmeter shows an output value of 3.26 V. All the other keypad values are listed on the table to the right of the schematics. If we connect the output to an oscillator, we can also observe the change in signal when a key is pressed.

Validation

The keypad behavior satisfies my project requirement, since the system would be able to distinguish between the different keys when it is being pressed. The MCU can take that information and use it to determine whether the right passcode is being entered, and whether or not an alarm needs to be sounded.

Device 4 – User Output: MILFORD-2X16-BKP (LCD Display)



Methodology

Driving the LCD with a virtual terminal, and connecting the transmitted pin TXD and the received pin RXD in the virtual terminal to the received pin RXD in the LCD to echo whatever send will come back type in the virtual terminal. The LCD will display the string typed in the virtual terminal.

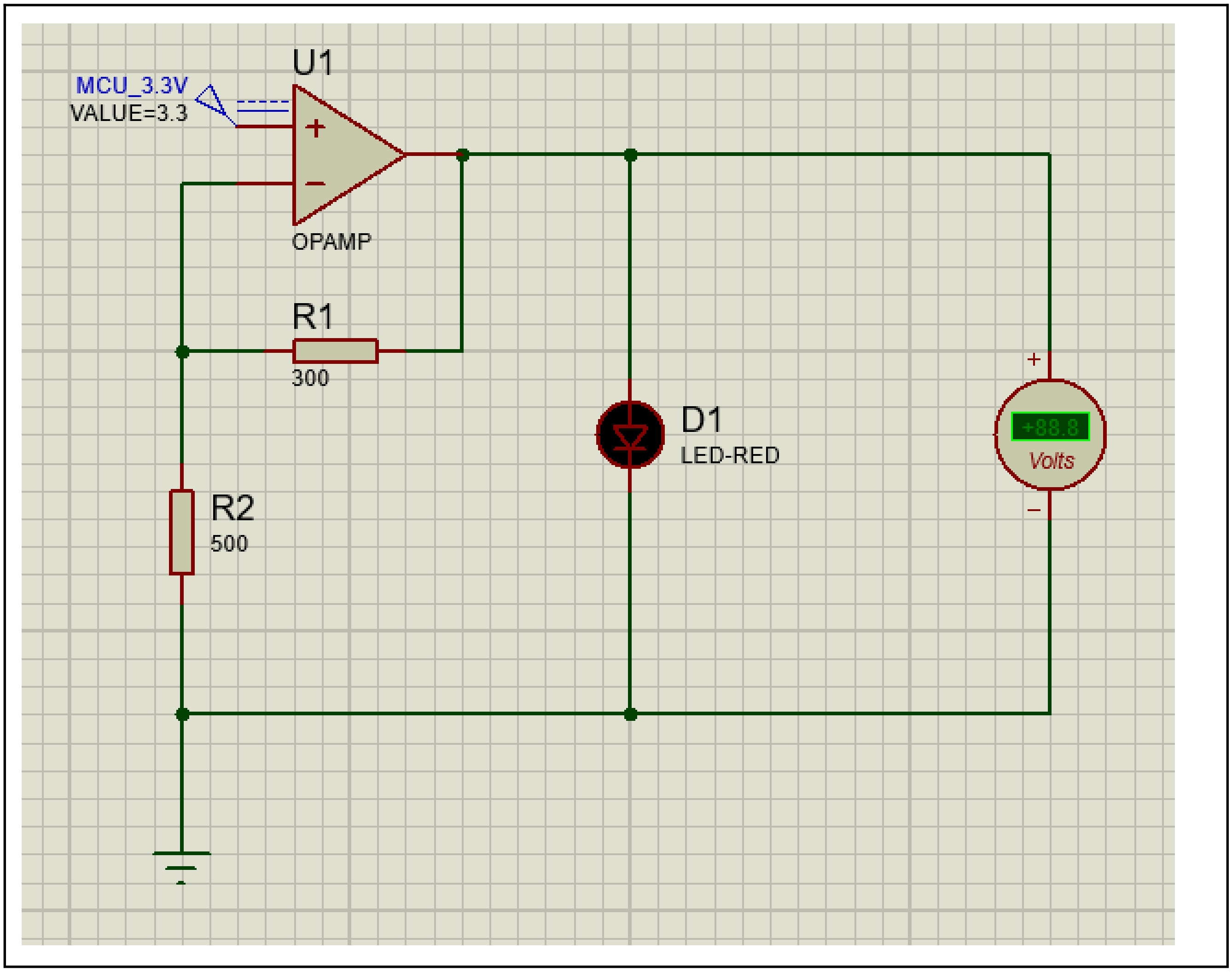
Verification

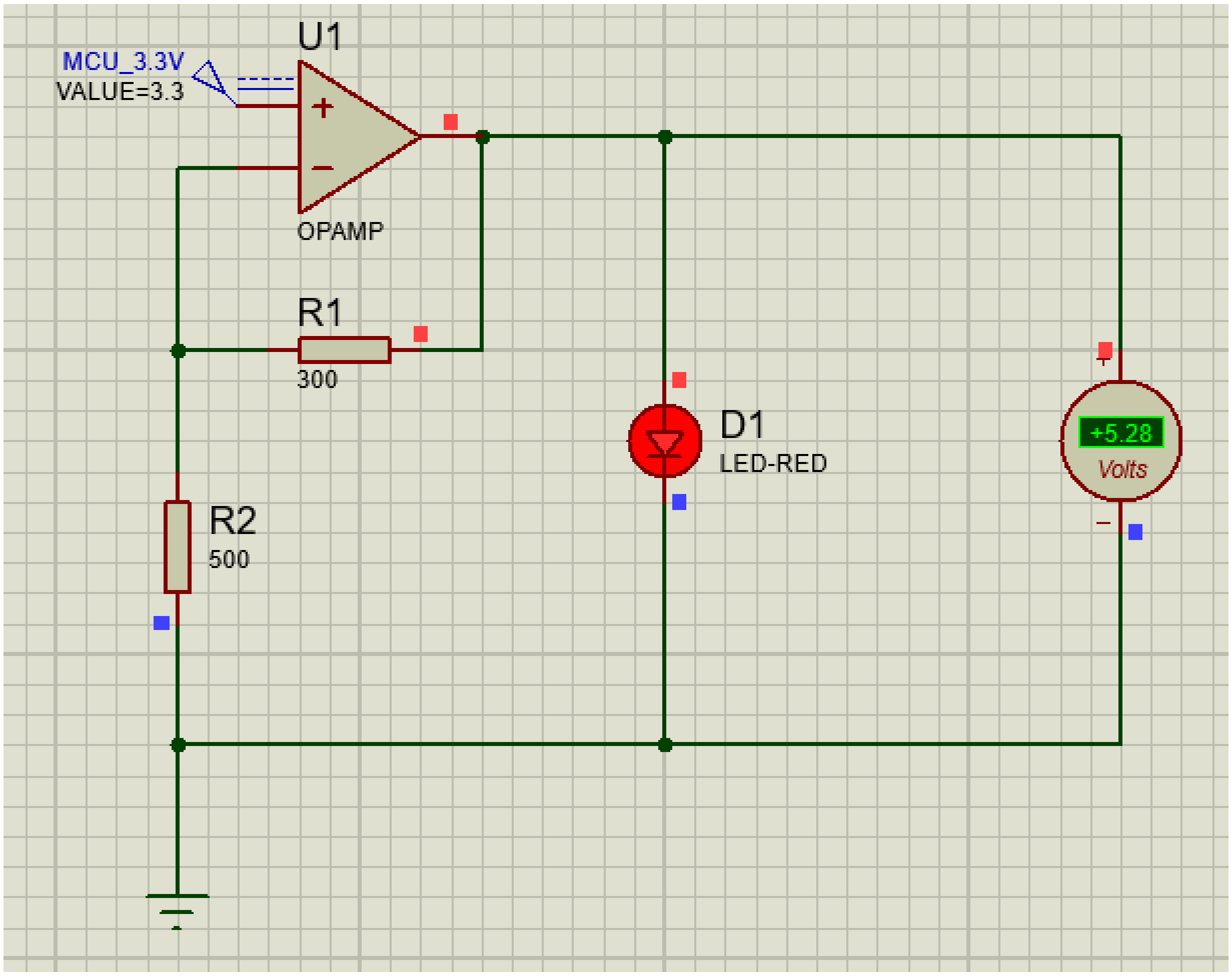
The message "Hi There!" is typed in the virtual terminal, and it is shown on the LCD display. The display will echo the string in the virtual terminal. It behaves as expected.

Validation

LCD display satisfies the project design requirement as it can display the Mode, Parameter Name and Parameter Value in Setup Mode and system sensor status during Run Mode by connecting it to the serial interface in the MCU. It can also show the system time and display all the information for every status.

Device 5 – LEDs


U1
MCU_3.3V
VALUE=3.3
OPAMP
R1
300
R2
500
D1
LED-RED
+88.8
Volts



Methodology

3.3V MCU output signal is connected to an Opamp to test the functionality of 5V LEDs. The LED will be turned on after running the simulation.

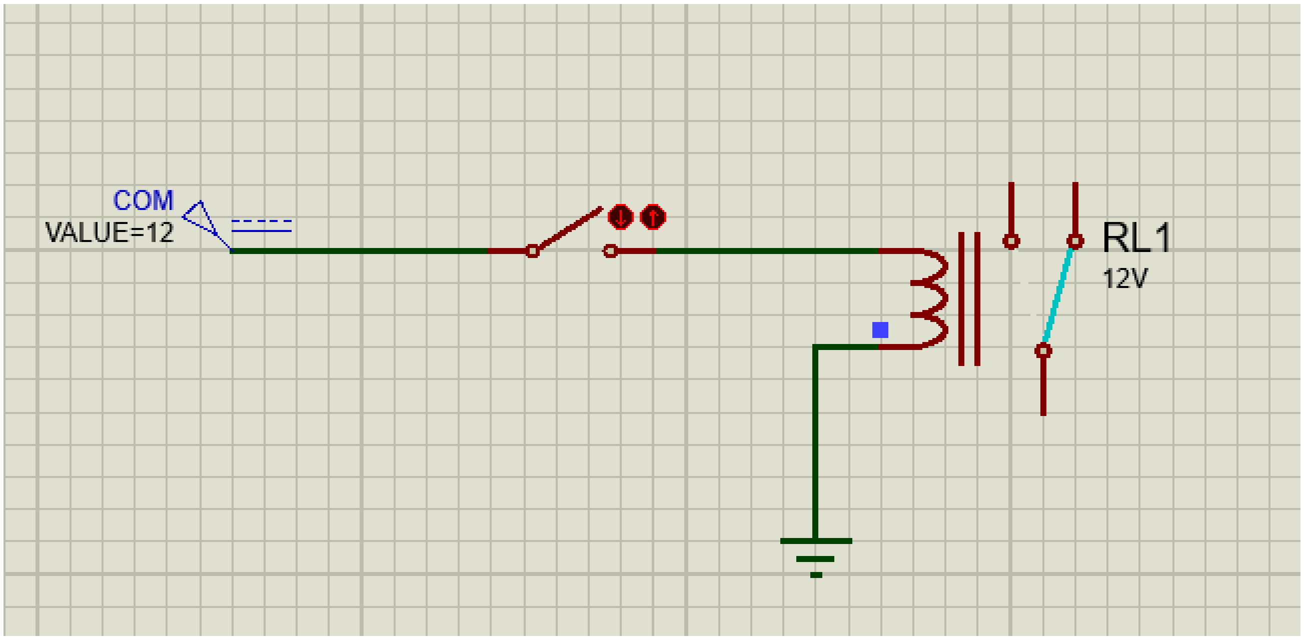
Verification

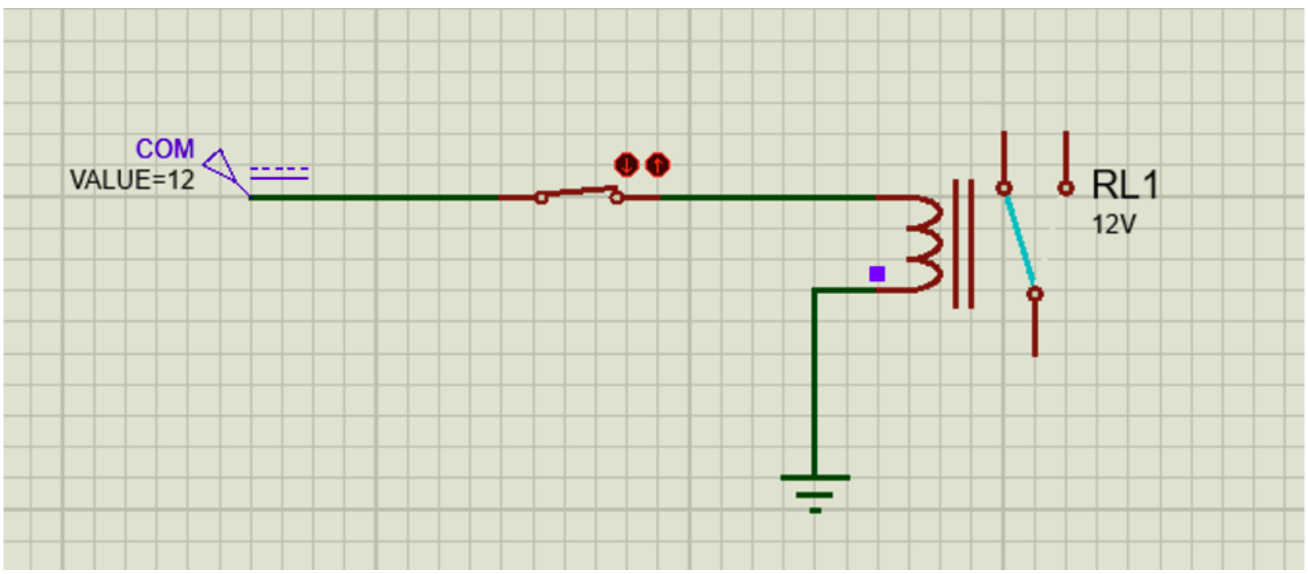
Before running the simulation, the LED is turned off, and there is no value on the voltmeter. After running the simulation, the LED is turned on, and the voltmeter can detect the voltage drop.

Validation

The LED satisfies our design requirement since MCU can control different LED colors to indicate the system status. We will use GREEN color to indicate ARMED, YELLOW color to indicate DISARMED, and RED color to indicate ALARM and SYSTEM ALARM.

Device 6 – Relays





Methodology

The 12V signal generator is used to test the relay. It is more interactive with a switch in the circuit. Relay works on the principle of electromagnetic induction. If the electromagnet has current flow through it, it will induce a magnetic field around it. The relay is connected to the outside world which is totally isolated from the inside circuit.

Verification

After running the simulation, if the switch is opened in the first figure, the relay is not engaged. If the switch is closed in the second figure, the relay will be engaged. It is isolated from the inside circuit. It behaved as expected.

Validation

The Relay satisfies the project requirement since they can control the external Audible ALARM and external lighting. The external lighting will be activated when a person approaches either of the entrances, and an external audible ALARM will be sound if any ALARM situation is triggered. They are electrically isolated from other electronic circuitry in the design to create flexibility for the user.

Part 4 – System-Level Design