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# ROOM CAPACITY READER

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CSE 321 – Real-Time Embedded Systems – Project 3

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BODHISWATTWA BASU  
State University of New York at Buffalo

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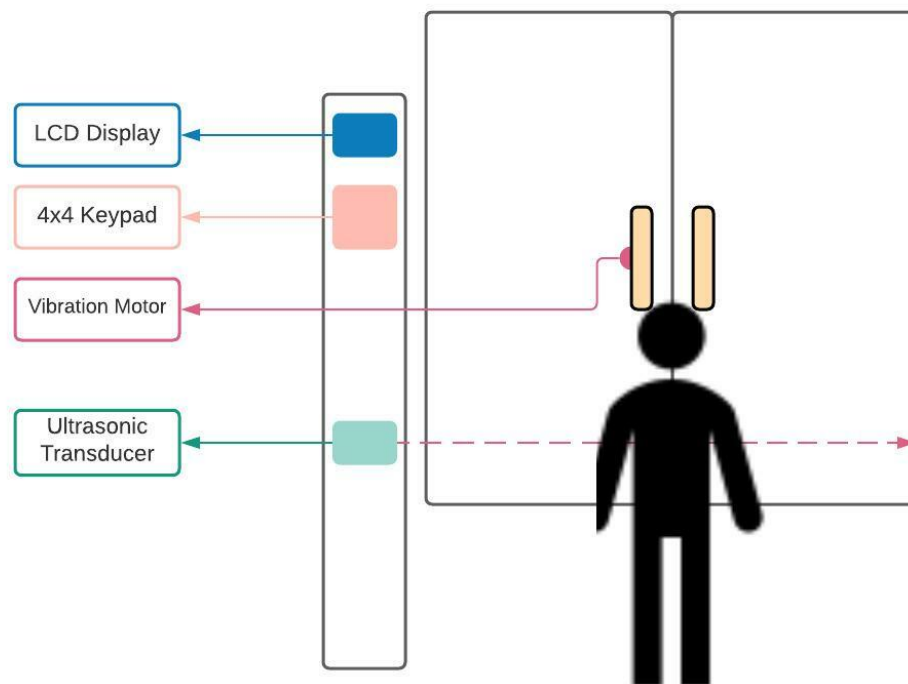
# INTRODUCTION

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After and during the course of the pandemic, the entire world had felt its effects. Restrictions on gatherings, events and crowds, in general, were implemented heavily to combat the spread of the deadly virus.

The Room Capacity Reader is a device that will deduct the capacity of the room by an ultrasonic transducer stationed at the entrance of the room. The administrator of the room will decide the capacity of the room which they can input in with the 4x4 keypad. The LCD display starts out with the initial number of people allowed in the room by the administrator. As people walk into the room, the LCD display will reduce the number of people allowed in the room. Once the capacity of the room is reached, the vibration motor that is attached to the door handle will activate and anyone trying to enter the room will feel the vibration on the door handle and be alerted by the LCD that the room has reached capacity.

Social distancing has allowed the world to return to its new “normal”. Keeping up with the practices that kept the world safe is important to the longevity of society and the economy.



*Figure 2 - Room Capacity Reader*

## SPECIFICATIONS AND FEATURES

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### LCD Screen

The LCD screen is the an output of the room capacity reader. It instructs the administrator on how to begin using the reader. It also displays the room capacity as it updates. Once the room has reached capacity, it displays so.

### 4x4 Keypad

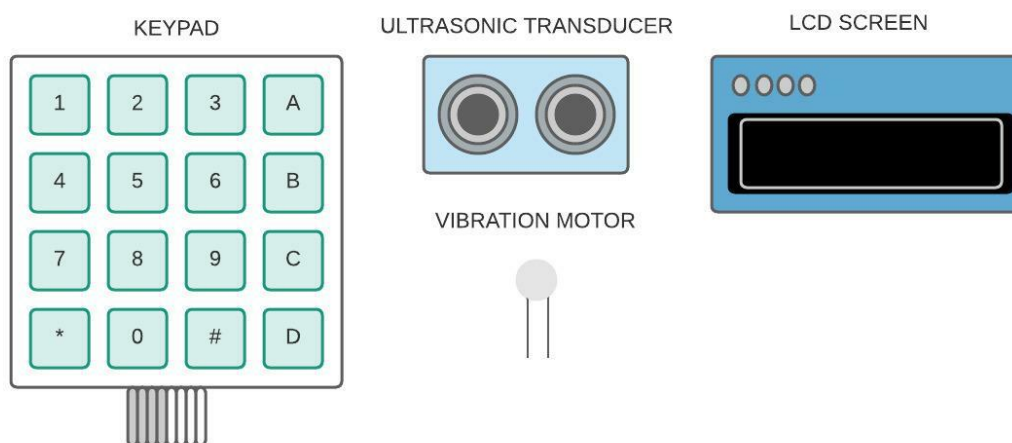
The 4x4 keypad is used by the administrator of the room to type in the room capacity and initiate the room capacity reader.

### Ultrasonic Transducer (HC-SR04)

The ultrasonic transducer detects when a person walks into the room. It triggers an ultrasonic sound wave every 10 microseconds and if, at any point, there's an echo that is received, it indicates a person's entrance into the room.

### Vibration Motor

Once the room reaches the desired administrator's capacity, the vibration motor attached to the door handle of the entrance will vibrate, alerting anyone who is trying to open the door, that the room is at capacity.



*Figure 2 – Features of Room Capacity Reader*

## WATCHDOG

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A watchdog timer is the last line of defense – a safeguard to protect against the system executing incorrectly. If left uninterrupted, the watchdog timer will reset the system. The watchdog timer was incorporated in the room capacity reader by resetting if there was a hardware fault – an issue with connections between the peripherals and the Nucleo-144.

## SYNCHRONIZATION TECHNIQUE

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The synchronization technique that is utilized are flags. Flags can be set or cleared according to the functionality. Room capacity reader utilizes four flags that are initially unset and once the function outputs correctly, the flag is set.

The flags and their purposes:

`flagA` — `flagA` is initially unset and once 'A' is pressed on the keypad, it sets.

`flagB` — `flagB` is initially unset and once 'B' is pressed on the keypad, it sets.

`flagC` — `flagB` is initially unset and `flagB` is set, it is then set.

`flagDone` — Once the countdown reads 0, the flag is set.

## BITWISE DRIVER CONFIGURATION

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In the room capacity reader, the 4x4 keypad and the vibration motor are bitwise configured. Bitwise driver configurations for the keypad were implemented in general purpose output mode to account for the interrupts incorporated in the columns of the 4x4 keypad. The vibration motor was also configured to general purpose output mode to vibrate once the room capacity reader has reached capacity.

The following are diagrams for the configuration:

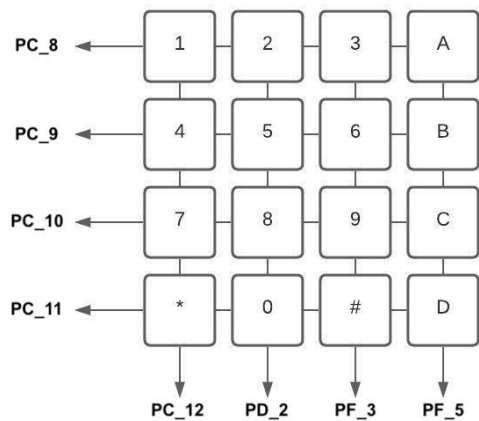


Figure 3 - Configuration of 4x4 Keypad



Figure 4 - Configuration of Vibration Motor

## INTERRUPTS

There were four interrupts incorporated into the room capacity reader. Each of the interrupts are incorporated into the columns of the 4x4 keypad. The interrupt in the columns trigger an event when a digital input pin changes.

## BLOCK DIAGRAM

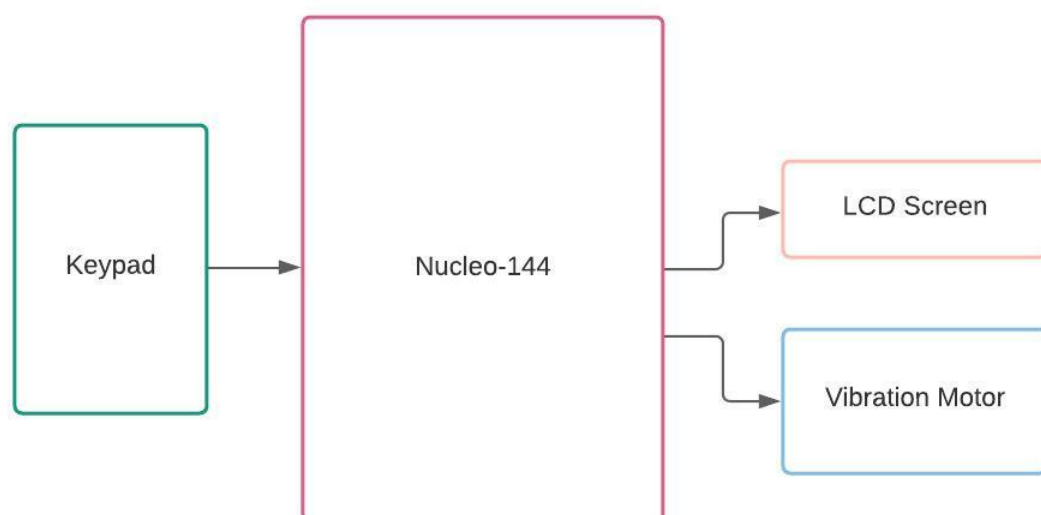


Figure 5 - Block Diagram

## BILL OF MATERIALS

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PERIPHERALS	DESCRIPTION	WHERE TO BUY
LCD Screen	LCD1602, liquid crystal display, is a kind of dot matrix module to show letters, numbers, and characters	<a href="#">Amazon</a>
Ultrasonic Transducer	HC-SR04 ultrasonic distance sensor.	<a href="#">Amazon</a>
Buzzer	Mechanical device to generate vibrations.	<a href="#">Amazon</a>
4x4 Keypad Matrix	The 4*4 matrix keypad module is a matrix keypad consisting of 16 keys in parallel.	<a href="#">Amazon</a>
Nucleo-L4R5ZI	STM32 Nucleo-144 board.	<a href="#">DigiKey</a>
Breadboard	Used to develop prototypes of electronic circuits.	<a href="#">Amazon</a>

## USER INSTRUCTIONS

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*Step 1:* Run the program.

*Step 2:* Press 'A' to begin typing in the room capacity.

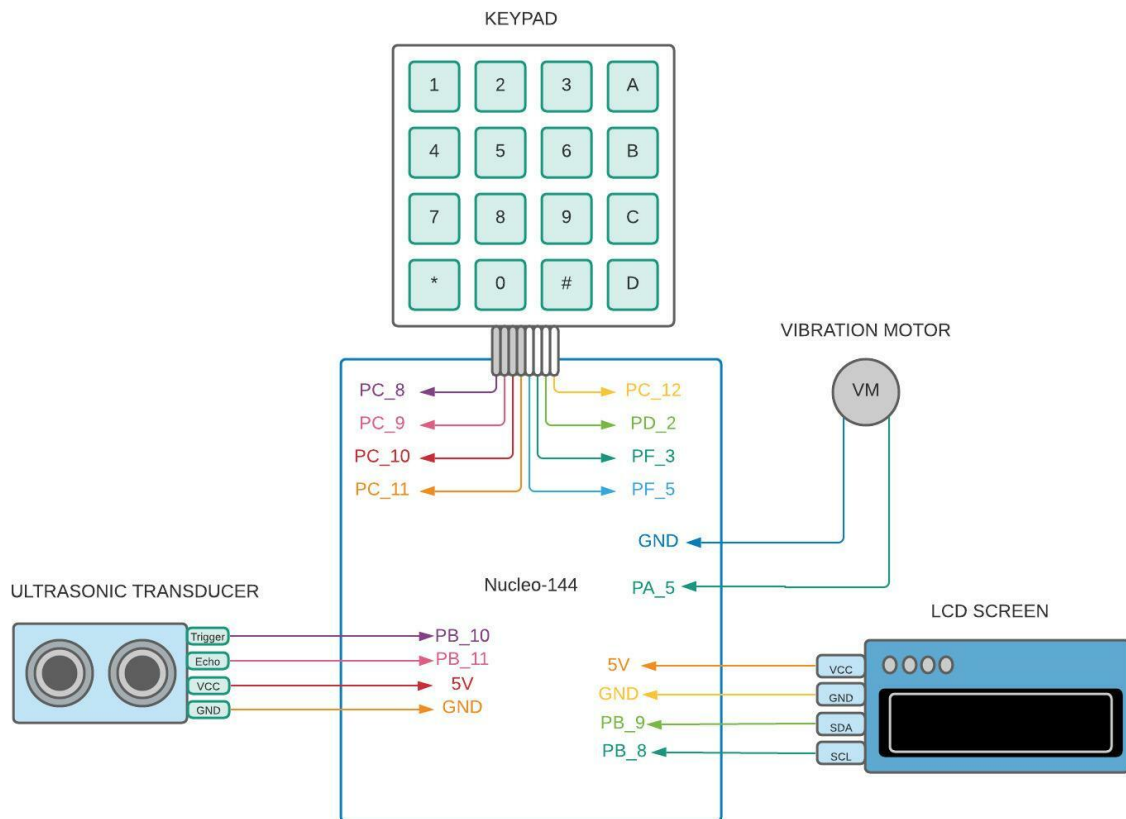
*Step 3:* User can now type in room capacity.

*Step 4:* Once user is done typing the room capacity in, user can press 'B' to start the ultrasonic transducer.

*Step 5:* Every time a person walks into the room, the room capacity reader will display the new room capacity.

*Step 6:* Once the room reaches capacity, the door's handle will vibrate from the vibration motor and the LCD will display 'Room Capacity Reached'.

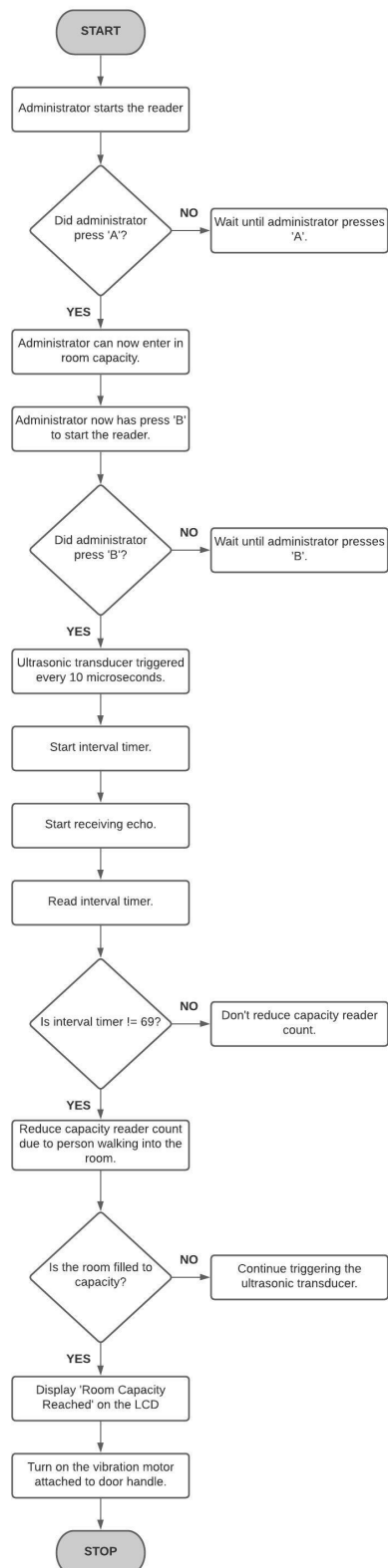
## SCHEMATIC



*Figure 6 - Schematic of Room Capacity Reader*



# FLOWCHART



## INSTRUCTIONS TO BUILD

*Step 1:* Connect jumper cables to appropriate connections according to schematics.

*Step 2:* Once connected, connect Nucleo-144 to computer to establish connection.

*Step 3:* Once connection is established, press 'Clean Build'.

*Step 4:* Once the program is built cleanly, press 'Run' to start the room capacity reader.

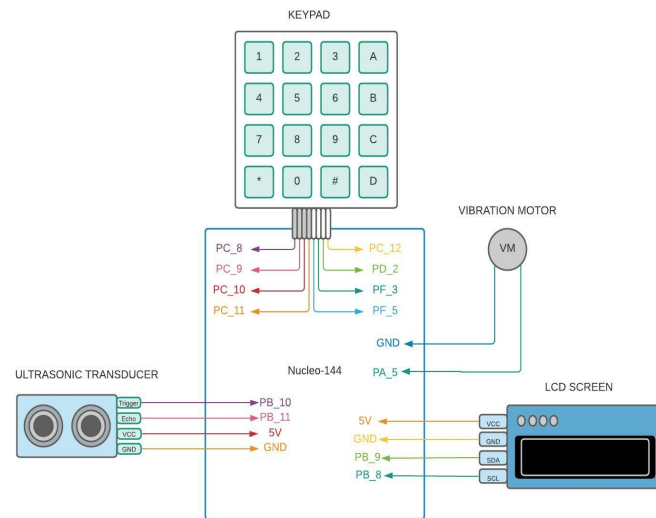


Figure 7 - Make appropriate connections

## TEST PLAN & OUTCOME OF IMPLEMENTATION

The following section of the report details the test plans that were implemented to adjust for the constraints of the project.

- **Test Plan #1: User should be able to press 'A' to enter room capacity.**

### Description:

Once the program executes, the user will be prompted by the LCD to 'Press A to enter room capacity'. If the user presses A, they will see the LCD screen display the current room capacity, 0, and then they can enter their desired room capacity.

### Results:

Initial LCD display: Press A to enter room capacity.

#### Subtest #1: Keypad press of key '1'

Final LCD display: Press A to enter room capacity.

#### Subtest #2: Keypad press of key 'B'

Final LCD display: Press A to enter room capacity.

#### Subtest #3: Keypad press of key '8'

Final LCD display: Press A to enter room capacity.

#### Subtest #4: Keypad press of key 'A'

Final LCD display: Room Capacity: 000

- **Test Plan #2: User should be able to press any number for values.**

Description:

Once the user has pressed 'A', they should be able to press any of the numeric keys on the keypad. Any alphabets pressed on the keypad should not register as keys.

Results:

Initial LCD display: Room Capacity: 000

Subtest #1: Keypad press of key 'A'

Final LCD display: Room Capacity: 000

Subtest #2: Keypad press of key 'B'

Final LCD display: Room Capacity: 000

Subtest #3: Keypad press of key '1'

Final LCD display: Room Capacity: 100

Subtest #4: Keypad press of key '0'

Final LCD display: Room Capacity: 100

- **Test Plan #3: User should press 'B' to start the room capacity reader.**

Description:

Once the user has pressed 'B', the ultrasonic transducer should start triggering. If the user has not pressed 'B', the LCD should display the room capacity entered in by the user.

Results:

Initial LCD display: Room Capacity: 100

Subtest #1: Keypad press of key 'A'

Final LCD display: Room Capacity: 100

Subtest #2: Keypad press of key '8'

Final LCD display: Room Capacity: 100

Subtest #3: Keypad press of key 'C'

Final LCD display: Room Capacity: 100

Subtest #4: Keypad press of key 'B'

Final LCD display: Room Capacity: 100

Final LCD display with obstruction: Room Capacity: 099

- **Test Plan #4: Obstruction should cause the room capacity counter to reduce.**

Description:

If a person is walking by the room capacity reader, the room capacity counter should reduce. If there is no person it should not reduce.

Results:

Initial LCD Display: Room Capacity: 100

Subtest #1: No obstruction

Final LCD display: Room Capacity: 100

Subtest #2: Obstruction

Final LCD display: Room Capacity: 099

Subtest #3: No obstruction

Final LCD display: Room Capacity: 099

Subtest #4: Obstruction

Final LCD display: Room Capacity: 098

Subtest #5: Obstruction

Final LCD display: Room Capacity: 097

Subtest #6: Obstruction

Final LCD display: Room Capacity: 096

- **Test Plan #5: Once room reaches capacity, vibration motor should vibrate.**

Description:

Once the room reaches capacity, the vibration motor that is connected to the door handle should vibrate.

Results:

Initial LCD Display: Room Capacity Reached!

Final LCD Display: Room Capacity Reached!

Vibration motor: On

## FUTURE CONSIDERATIONS

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For future considerations of this implementation, bringing forth a design that should include people with accessibility needs is important. This requires the use of other phonic, auditory or visual aids.

An important addition to the room capacity reader would be another ultrasonic sensor that would be stationed on the inside of the door. The door, in this case, would not require it to be an entrance, and can be bidirectional, which would make the room capacity reader much more functional.