Department of Electrical Engineering
Indian Institute of Technology Delhi

ELL 365 Project

Lift controller

Group 3

Contents

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Table 2: Hardware Team

2 Introduction

The Lift Controller Project aims to design and implement an efficient and reliable system for controlling the operation of elevators in a building. Elevators, or lifts, are essential components of modern infrastructure, facilitating transportation within multi-story buildings. The primary objective of this project is to develop a controller that optimizes elevator movement.

Key Components:

1. Control Algorithm: The heart of the lift controller system lies in its control algorithm. This algorithm determines the optimal movement of elevator in response to user requests, considering factors such as passenger load, destination floors.
2. User Interface: A user-friendly interface allows passengers to input their desired destination floors and interact with the elevator system. This interface may include buttons inside the elevator cabin, as well as external call buttons located on each floor.
3. Safety Features: Safety is paramount in lift controller design. The system incorporates safety mechanisms to prevent accidents, such as emergency stop buttons.

Project Goals:

1. Reliability: The system must operate reliably under varying loads and conditions, ensuring smooth and uninterrupted vertical transportation within the building.
2. Scalability: The lift controller should be scalable to accommodate buildings of different sizes and configurations, from small residential buildings to large commercial complexes.
3. Safety: Safety is a top priority, and the system must comply with industry standards and regulations to ensure the well-being of passengers and personnel.
4. Accessibility: The user interface should be accessible to passengers of all ages and abilities, with clear signage and intuitive controls.

By achieving these goals, the Lift Controller Project aims to enhance the efficiency, reliability, and safety of elevator systems, ultimately improving the user experience and optimizing vertical transportation in buildings.

3 Materials Required

In the simulation

- ESP 32 controller
- LEDs
- Resistors
- Switches
- Keypad
- LCD Screen

In the real circuit

- Motor
- Motor Driver Circuits
- Siren/ Alarm (for emergency call feature)

4 Specifications and Assumptions

- **Initial Conditions:**
  The lift commences its operation from the **5th** floor.

- **Timing Parameters:**

  - **Time to Move Between Floors:** The lift takes **10 seconds** to travel between adjacent floors.
  - **Time to Open Doors:** Upon reaching a floor, the doors open within **2 seconds.**
  - **Time of Stay at a Floor:** After the doors open, the lift remains stationary for **5 seconds** to allow passengers to enter or exit.
  - **Time to Close Doors:** Subsequently, the doors close within **2 seconds** to prepare for departure.

- **Number of Floors:**
  The building comprises **10 floors**, ranging from the ground floor (0) to the top floor (9).

5 Finite State Machine (FSM) details

5.1 Motivation / Explanation

Our FSM has three states which are mapped to three floors. The mapping is as follows :

State	Floor
q_0	1
q_1	2
q_2	3

The mapping from inputs to buttons are as follows :

Input	Button pressed
00	Floor 1
01	Floor 2
10	Floor 3
11	Emergency stop

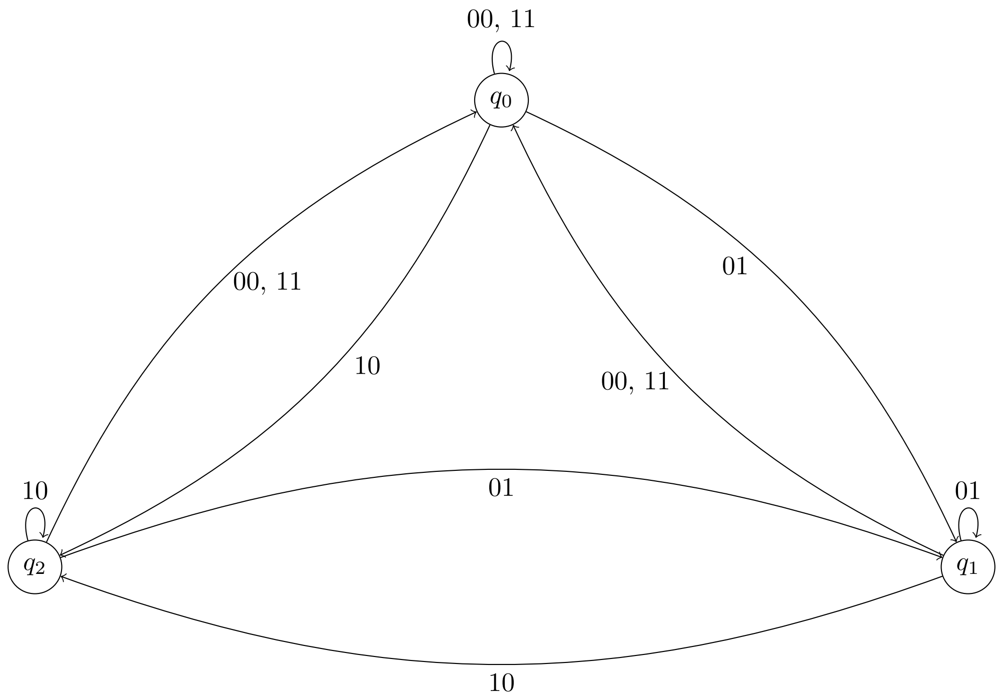
Note that the following actions are not represented in the FSM :

- Fast open / close : Does not involve change of state
- Emergency call : Does not involve state change
- Any floor button inputs received during transition from one floor to another: The inputs are not ignored and the controller acts on them but since they affect state change some time later and not immediately so they are not shown in the FSM

5.2 Transition table

Current State	**Input**	**Next State**
q_0	00	q_0
q_0	01	q_1
q_0	10	q_2
q_0	11	q_0
q_1	00	q_0
q_1	01	q_1
q_1	10	q_2
q_1	11	q_0
q_2	00	q_0
q_2	01	q_1
q_2	10	q_2
q_2	11	q_0

5.3 Transition Diagram



6 Description and working

6.1 Main components

- ESP32 controller
- LED light that flashes when the Emergency Call is pressed
- Keypad with buttons for entering floor number. This would be installed inside the lift.
- LCD screen for display

6.2 Key Features

- The user presses button on keypad to go to corresponding floor. For purpose of presentation and analysis it is mapped for 3 floors, but it can be mapped for upto 10 floors.
- Fast open / close : User can press the B button to close the lift doors quickly. Similarly he can press the A button to open/reopen the doors.
- Emergency call : User can press this button to send a distress signal. In our code it is implemented as a flashing LED. In real life it is usually a siren outside the lift.
- Scalability : By changing the parameters defined in lines 15 to 20 of the code , we can change the number of floors, delay between floors, door opening delay, door closing delay and the amount of time we stay on the floor. The simulation assumes we start the lift at floor 5 but this can be changes at line 24.
- Micropython language is used and the assumed parameters are specified at the top of the code

6.3 Working

- The lift opens initially at the specified floor (for eg 5) and waits for next input.
- When it receives input to go to a floor (say floor 1) then it moves to that floor and the LCD shows all the floors in between as well (Moving to floor 4 for eg)

- Lift reaches the destination and opens and then closes, with the specified delay.
- If the a button for another floor is pressed during transit, then one of two occurs:
  - If the new inout floor lies on the current path , (i.e floor 5 to 1 path) then the lift stops at that floor as well.
  - Else if it is in the other direction (say floor 6), then the lift stores the new floor in a list and it first goes to floor 1 and then visits floor 6.
  - Emergency stop : This button immediately interrupts the lift operation and takes the lift to floor 1.
  - The other three buttons : Emergency Call, Fast open, and Fast close work as described in Section 6.2.

7 Simulation

7.1 Wokwi link

https://wokwi.com/projects/395127693038423041

7.2 Code

Note : Both the below versions differ only at line 15, attesting to the scalability of the code.

7.2.1 3 floor version

```
1  from time import sleep_ms
2  from machine import Pin, SoftI2C
3  from i2c_lcd import I2cLcd
4  import time
5  from utime import sleep
6  ######## Definitions ########
7  
8  # Define LCD params
9  AddressOfLcd = 0x27
10 i2c = SoftI2C(scl=Pin(22), sda=Pin(21), freq=400000) # connect scl to GPIO 22, sda to GPIO 21
11 lcd = I2cLcd(i2c, AddressOfLcd, 4, 20)
12 led = Pin(15, Pin.OUT)
13 
14 #Assumptions
15 No_of_floors = 3
16 floor_floor_delay = 10
17 floor_opening_delay = 2
18 floor_closing_delay = 2
19 floor_stay_delay = 5
20 floors = []
21 for i in range(0, No_of_floors,1):
22     floors.append(str(i))
23 print(floors)
24 initial_pos = 5
25 
26 # Define keypad layout
27 
28 # O -- Fast Open
29 # C -- Fast Close
30 # A -- Alarm
31 # E -- Emergency Stop
32 # * && / -- Undefined states
33 # 0,1,2,3,4,5, 6,7,8,9 -- Floor States
34 
35 keypad = [
36     ['1', '2', '3', 'O' ],
37     ['4', '5', '6', 'C' ],
38     ['7', '8', '9', '*' ],
39     ['A', '0', 'E', '/' ]
40 ]
```

```python

# Define the row and column pins
row_pins = [Pin(13, Pin.OUT), Pin(12, Pin.OUT), Pin(14, Pin.OUT), Pin(27, Pin.OUT)]
col_pins = [Pin(26, Pin.IN, Pin.PULL_UP), Pin(25, Pin.IN, Pin.PULL_UP), Pin(33, Pin.IN, Pin.PULL_UP), Pin(32, Pin.IN, Pin.PULL_UP)]

# Initialize the row pins to HIGH
for row_pin in row_pins:
    row_pin.value(1)

# Initialize the col pins to LOW
for col_pin in col_pins:
    col_pin.value(0)

# Variables to store user input and calculation
user_input = ""
result = None
math_sign = ""
sign_applied = False    # When sign button has not been clicked

####### Methods ########
# Pad String
def pad_string(input_string, desired_length = 15):
    current_length = len(input_string)
    if current_length >= desired_length:
        return input_string  # No need to pad if it's long enough

    # Calculate the number of spaces needed
    spaces_needed = desired_length - current_length

    # Append the required spaces to the string
    padded_string = input_string + " " * spaces_needed

    return padded_string

# Print user input
def lcd_print(row, value, start_col = 1, space_padding = True):
    print("move to : " + str(row))
    lcd.move_to(start_col,row)
    if space_padding:
        lcd.putstr(pad_string(str(value)))
    else:
        lcd.putstr(str(value))

# Get Key Pressed value
def get_key():
    keys_detected = []
    for i, row_pin in enumerate(row_pins):
        # Drive the current row LOW
        row_pin.value(0)

        for j, col_pin in enumerate(col_pins):
            if col_pin.value() == 0:
                keys_detected.append(keypad[i][j])
                # Key is pressed, return the corresponding character
                return keypad[i][j]


        # Release the row
        row_pin.value(1)

    return None

disk_size = 200
def SCAN(arr, head, direction):
    seek_count = 0
    distance , cur_track = 0, 0
    left = []
    right = []
    seek_sequence = []

    # if(direction == "left"):
    #     left.append(0)
```

```python
    # elif(direction == "right"):
    #     right.append(disk_size-1)
    for i in range(len(arr)):
        if(arr[i] <= head):
            left.append(arr[i])
        if(arr[i] > head):
            right.append(arr[i])

    left.sort()
    right.sort()

    run = 2
    while(run !=0):
        if(direction == "left"):
            for i in range(len(left)-1, -1 ,-1):
                cur_track = left[i]
                seek_sequence.append(cur_track)
                distance = abs(cur_track - head)
                seek_count += distance

                head = cur_track
            direction = "right"
        elif(direction == "right"):
            for i in range(len(right)):
                cur_track = right[i]
                seek_sequence.append(cur_track)
                distance = abs(cur_track - head)
                seek_count += distance
                head = cur_track
            direction = "left"
        run -= 1
    arr.clear()
    for i in range(len(seek_sequence)):
        arr.append(seek_sequence[i])
        if( i != 0 and seek_sequence[i] == seek_sequence[i-1]):
            arr.pop()
arr = []
head = initial_pos
direction = "left"




# Run keyboard scan
def keyboard_scan():
    global user_input
    global result
    global math_sign
    global sign_applied

    key = get_key()
    if key is not None:
        if key in floors:
            arr.append(int(key))
            SCAN(arr, head, direction)
            for i in range(len(arr)):
                print(arr[i])
        elif key == "E":
            arr.clear()
            lcd.clear()
            lcd_print(2, "Emergency Stop", 0, False)
        elif key == "A":
            led.on()
            sleep(2)
            led.off()
        elif key == "O":
            print("Fast Open Initiated")
        elif key == "C":
            print("Fast Close Initiated")
        else:
            print("Invalid Button Pressed")
    # Add a small delay to debounce the keypad
    sleep_ms(100)
```

```python
    return key

lcd_print(2, "Floor 5 closing Door", 0, False)



while True:
    while(len(arr) != 0):
        if(arr[0] - head  > 0):
            head +=1

            lcd.clear()
            lcd_print(2, "Moving to floor: " + str((head)), 0, False)
            start_time = time.time()
            while time.time() - start_time <floor_floor_delay:
                key = keyboard_scan()
                if(key == "E"):
                    continue
                sleep_ms(100)
        elif(arr[0] - head < 0):
            head -=1

            lcd.clear()
            lcd_print(2, "Moving to floor: " + str((head)), 0, False)
            start_time = time.time()
            while time.time() - start_time <floor_floor_delay:
                key = keyboard_scan()
                if(key == "E"):
                    continue
                sleep_ms(100)
        else:
            lcd.clear()
            lcd_print(2, "FLoor "+ str((head)) + " Opening Door", 0, False)
            start_time = time.time()
            key = '-'
            while time.time() - start_time <floor_opening_delay:
                keyboard_scan()
                sleep_ms(100)
            start_time = time.time()
            lcd.clear()
            lcd_print(2, "Floor " + str((head)) + " Reached", 0, False)
            while time.time() - start_time <floor_stay_delay:
                key = keyboard_scan()
                if(key == "C" or key == "O"):
                    break

                sleep_ms(100)
            if(key != "O"):
                lcd.clear()
                lcd_print(2, "FLoor "+ str((head)) + " Closing Door", 0, False)
            start_time = time.time()
            while time.time() - start_time <floor_closing_delay:
                key = keyboard_scan()
                if(key  == "O"):
                    break
                sleep_ms(100)
            if(key != "O"):
                arr.pop(0)


    keyboard_scan()
    sleep_ms(100)
```

liftcontroller_3.py

7.2.2 10 floor version

```
from time import sleep_ms
from machine import Pin, SoftI2C
from i2c_lcd import I2cLcd
import time
from utime import sleep
######## Definitions ########

# Define LCD params
AddressOfLcd = 0x27
i2c = SoftI2C(scl=Pin(22), sda=Pin(21), freq=400000) # connect scl to GPIO 22, sda to GPIO 21
lcd = I2cLcd(i2c, AddressOfLcd, 4, 20)
led = Pin(15, Pin.OUT)

#Assumptions
No_of_floors = 10
floor_floor_delay = 10
floor_opening_delay = 2
floor_closing_delay = 2
floor_stay_delay = 5
floors = []
for i in range(0, No_of_floors,1):
    floors.append(str(i))
print(floors)
initial_pos = 5

# Define keypad layout

# O -- Fast Open
# C -- Fast Close
# A -- Alarm
# E -- Emergency Stop
# * && / -- Undefined states
# 0,1,2,3,4,5, 6,7,8,9 -- Floor States

keypad = [
    ['1', '2', '3', 'O' ],
    ['4', '5', '6', 'C' ],
    ['7', '8', '9', '*' ],
    ['A', '0', 'E', '/' ]
]

# Define the row and column pins
row_pins = [Pin(13, Pin.OUT), Pin(12, Pin.OUT), Pin(14, Pin.OUT), Pin(27, Pin.OUT)]
col_pins = [Pin(26, Pin.IN, Pin.PULL_UP), Pin(25, Pin.IN, Pin.PULL_UP), Pin(33, Pin.IN, Pin.PULL_UP), Pin(32, Pin.IN, Pin.PULL_UP)]

# Initialize the row pins to HIGH
for row_pin in row_pins:
    row_pin.value(1)

# Initialize the col pins to LOW
for col_pin in col_pins:
    col_pin.value(0)

# Variables to store user input and calculation
user_input = ""
result = None
math_sign = ""
sign_applied = False    # When sign button has not been clicked

####### Methods ########
# Pad String
def pad_string(input_string, desired_length = 15):
    current_length = len(input_string)
    if current_length >= desired_length:
        return input_string  # No need to pad if it's long enough

    # Calculate the number of spaces needed
    spaces_needed = desired_length - current_length

```

```
    # Append the required spaces to the string
    padded_string = input_string + " " * spaces_needed

    return padded_string

# Print user input
def lcd_print(row, value, start_col = 1, space_padding = True):
    print("move to : " + str(row))
    lcd.move_to(start_col,row)
    if space_padding:
        lcd.putstr(pad_string(str(value)))
    else:
        lcd.putstr(str(value))

# Get Key Pressed value
def get_key():
    keys_detected = []
    for i, row_pin in enumerate(row_pins):
        # Drive the current row LOW
        row_pin.value(0)

        for j, col_pin in enumerate(col_pins):
            if col_pin.value() == 0:
                keys_detected.append(keypad[i][j])
                # Key is pressed, return the corresponding character
                return keypad[i][j]


        # Release the row
        row_pin.value(1)

    return None

disk_size = 200
def SCAN(arr, head, direction):
    seek_count = 0
    distance , cur_track = 0, 0
    left = []
    right = []
    seek_sequence = []

    # if(direction == "left"):
    #     left.append(0)
    # elif(direction == "right"):
    #     right.append(disk_size -1)
    for i in range(len(arr)):
        if(arr[i] <= head):
            left.append(arr[i])
        if(arr[i] > head):
            right.append(arr[i])

    left.sort()
    right.sort()

    run = 2
    while(run !=0):
        if(direction == "left"):
            for i in range(len(left)-1, -1 ,-1):
                cur_track = left[i]
                seek_sequence.append(cur_track)
                distance = abs(cur_track - head)
                seek_count += distance

                head = cur_track
            direction = "right"
        elif(direction == "right"):
            for i in range(len(right)):
                cur_track = right[i]
                seek_sequence.append(cur_track)
                distance = abs(cur_track - head)
                seek_count += distance
                head = cur_track
            direction = "left"
```

```
        run -= 1
    arr.clear()
    for i in range(len(seek_sequence)):
        arr.append(seek_sequence[i])
        if( i != 0 and seek_sequence[i] == seek_sequence[i-1]):
            arr.pop()
arr = []
head = initial_pos
direction = "left"




# Run keyboard scan
def keyboard_scan():
    global user_input
    global result
    global math_sign
    global sign_applied

    key = get_key()
    if key is not None:
        if key in floors:
            arr.append(int(key))
            SCAN(arr, head, direction)
            for i in range(len(arr)):
                print(arr[i])
        elif key == "E":
            arr.clear()
            lcd.clear()
            lcd_print(2, "Emergency Stop", 0, False)
        elif key == "A":
            led.on()
            sleep(2)
            led.off()
        elif key == "O":
            print("Fast Open Initiated")
        elif key == "C":
            print("Fast Close Initiated")
        else:
            print("Invalid Button Pressed")
    # Add a small delay to debounce the keypad
    sleep_ms(100)
    return key

lcd_print(2, "Floor 5 closing Door", 0, False)



while True:
    while(len(arr) != 0):
        if(arr[0] - head  > 0):
            head +=1

            lcd.clear()
            lcd_print(2, "Moving to floor: " + str((head)), 0, False)
            start_time = time.time()
            while time.time() - start_time <floor_floor_delay:
                key = keyboard_scan()
                if(key == "E"):
                    continue
                sleep_ms(100)
        elif(arr[0] - head < 0):
            head -=1

            lcd.clear()
            lcd_print(2, "Moving to floor: " + str((head)), 0, False)
            start_time = time.time()
            while time.time() - start_time <floor_floor_delay:
                key = keyboard_scan()
                if(key == "E"):
                    continue
                sleep_ms(100)
```

```python
        else:
            lcd.clear()
            lcd_print(2, "FLoor "+ str((head)) + " Opening Door", 0, False)
            start_time = time.time()
            key = '-'
            while time.time() - start_time <floor_opening_delay:
                keyboard_scan()
                sleep_ms(100)
            start_time = time.time()
            lcd.clear()
            lcd_print(2, "Floor " + str((head)) + " Reached", 0, False)
            while time.time() - start_time <floor_stay_delay:
                key = keyboard_scan()
                if(key == "C" or key == "O"):
                    break

                sleep_ms(100)
            if(key != "O"):
                lcd.clear()
                lcd_print(2, "FLoor "+ str((head)) + " Closing Door", 0, False)
            start_time = time.time()
            while time.time() - start_time <floor_closing_delay:
                key = keyboard_scan()
                if(key  == "O"):
                    break
                sleep_ms(100)
            if(key != "O"):
                arr.pop(0)


    keyboard_scan()
    sleep_ms(100)
```

liftcontroller_10.py

7.3 Circuit

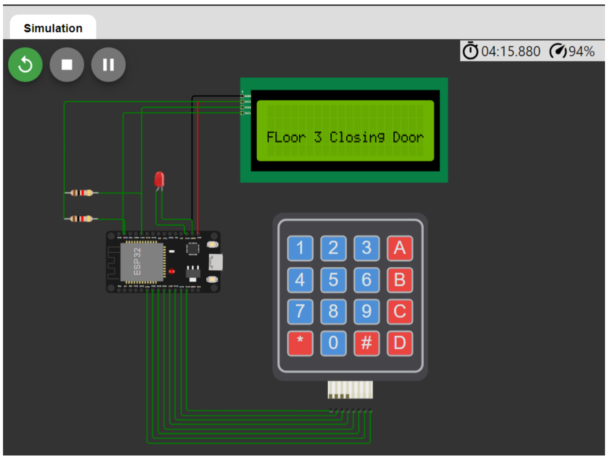


Figure 1: Full circuit

7.4 Screenshots during operation

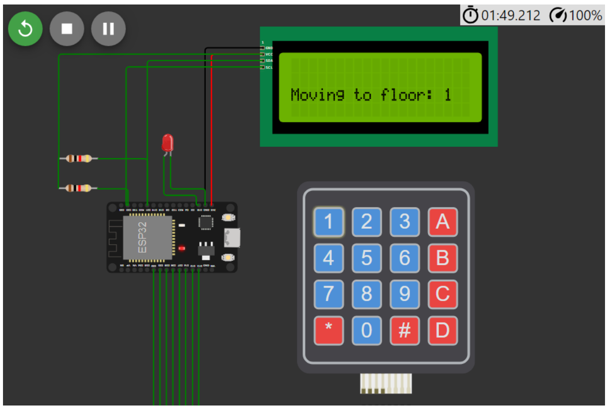


Figure 2: Moving to floor 1

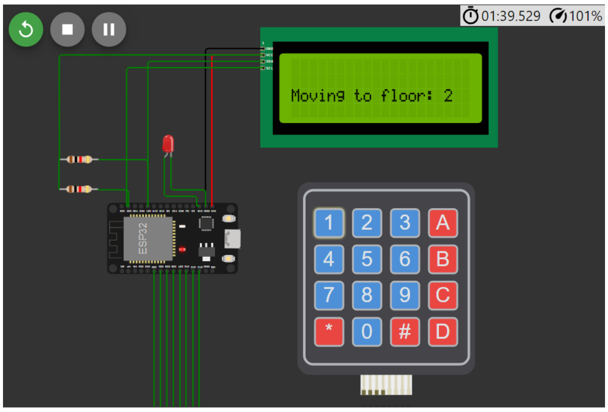


Figure 3: Moving to floor 2

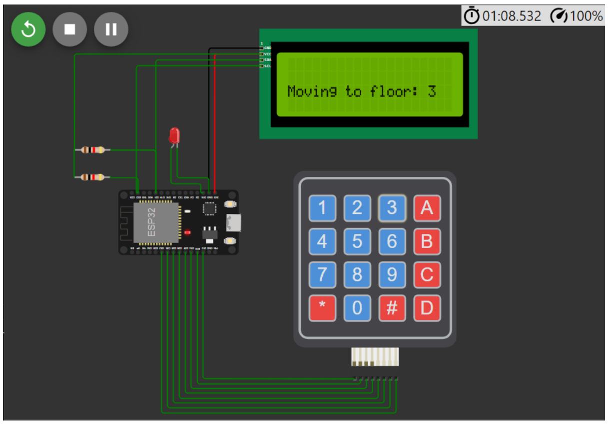


Figure 4: Moving to floor 3

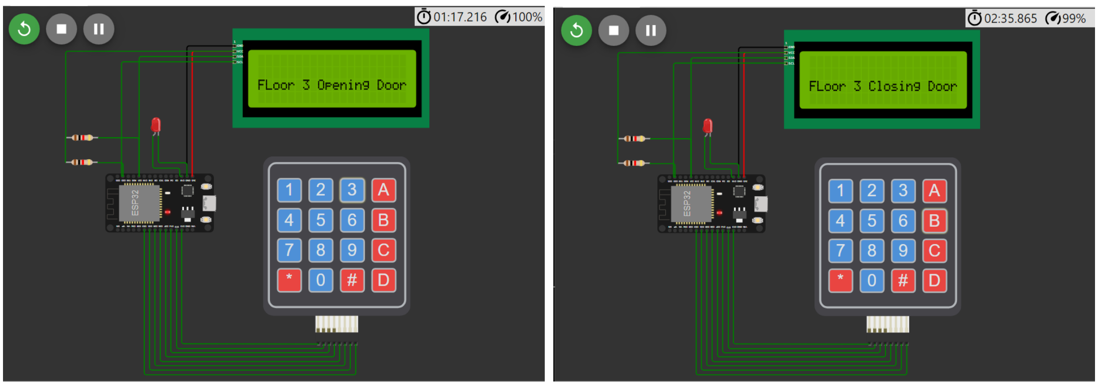


Figure 5: Opening and closing lift doors

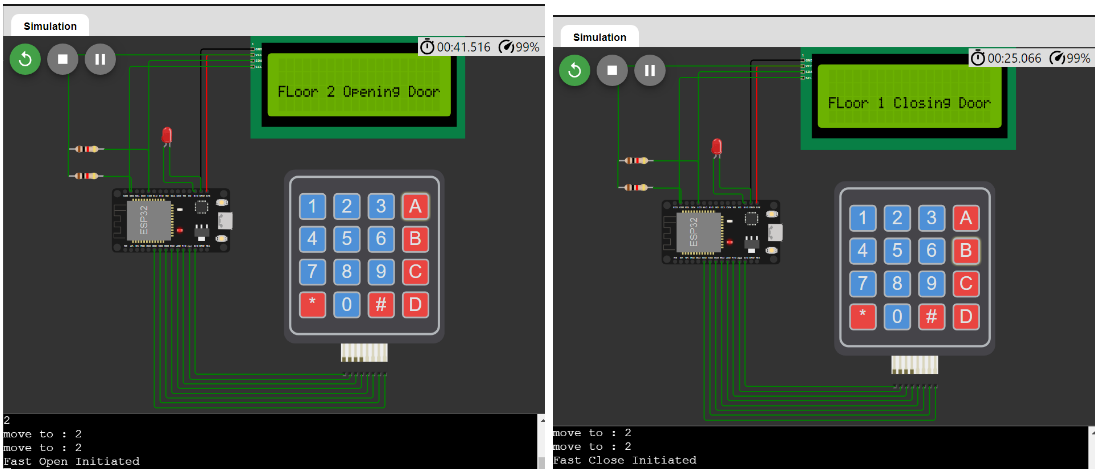


Figure 6: Fast open (key 'A') and Fast close (key 'B')

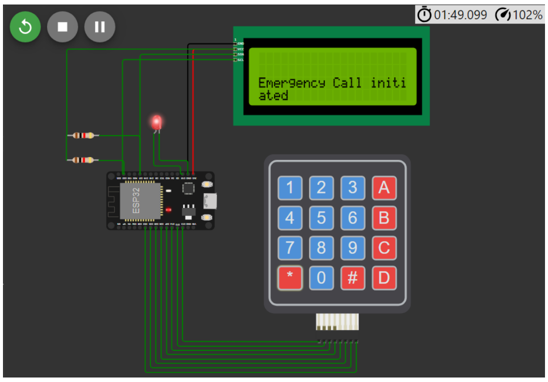


Figure 7: Emergency call and the glowing LED (key '*')

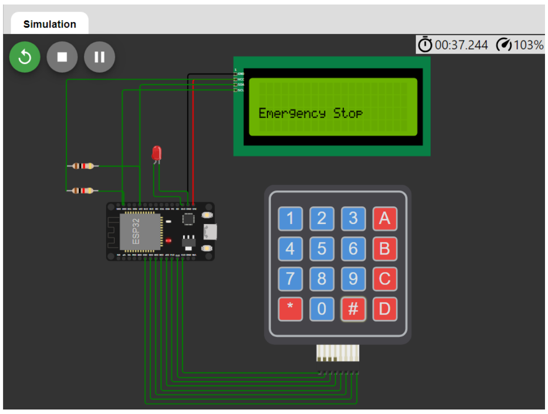


Figure 8: Emergency stop (key '#')

8 Possible improvements

1. **Deselect Option** The lift could have a deselect option such that if a person selects the wrong button, he has the option to deselect it and select the correct one.
   In a case if the lift has started moving, and then the button is deselected, the lift will move in the same direction, stop on the nearest floor and then continue moving according to the remaining selected buttons.

2. **Outer lift control panel** The lift setup may include an external control panel for calling the lift.

3. **Non-Stop setting** The lift control panel may have a non-stop setting for a case in which the lift is needed to operate from the ground floor directly to the third and subsequent floor (i.e. it doesn't stop in between the ground floor to the third floor)

9 Conclusion

The Lift Controller Project is all about creating a system that makes elevators in buildings work smoothly and safely. We've put together different parts like the controller, keypad, lights, and screen to make it easy for people to use and to alert for emergencies.

The system follows a plan for how long things take, like moving between floors or opening and closing doors. This helps everything run smoothly and keeps people moving comfortably. Also, we've added features like quick door buttons and an emergency call button to make it even better.

To summarize, while our current lift controller meets basic requirements, further enhancements are necessary to optimize functionality, efficiency, and safety. These improvements will create a more sophisticated and reliable lift system that meets modern user expectations.

Glossary

ESP 32 Microcontroller. 5

FSM A Finite State Machine, or FSM, is a computation model that can be used to simulate sequential logic. Here we have used to model the lift controller system.. 6

LCD Liquid Crystal Display.. 5

Micropython MicroPython is a programming language largely compatible with Python 3, written in C, that is optimized to run on a microcontroller.. 7

Motor Driver Circuits Motor driver circuitry typically includes an integrated circuit that can supply enough current to drive the motor, while also providing shaft control for precise speed adjustment.. 5

A Appendix 1: Document Statistics

- Word Count: 4430
- Number of Sentences: 380
- Number of Characters: 24963

B Appendix 2: Readability Indices

- **Readability Index[1]:** 1.4

  This means that this text can be understood by children who can read books with chapters.

- **Gunning-Fog Index[2]:** 7.4

  This means that the text can be easily understood by someone who has passed grade 8, US education standards.

- **Flesch Reading Ease[3]:** 87
  This means that this text can be understood by 12-13 year olds.

- **Coleman Liau Index[4]:** 5.6

  This means that the text can be easily understood by someone who has passed grade 10, US education standards.

[1] The readability index indicates the approximate reading grade level of a text based on the US education system. The formula takes into account characters in a given word and the words in a given sentence. It varies from 0 - 16+.

[2] On a scale from 0 -20, the Gunning-Fog Index is a weighted average of the number of words per sentence and the number of long words per word. This can be understood as the text can be understood by someone who left full-time education at a later age than the index. Hence a lower Gunning-Fog index is easier to read.

[3] The Flesch Reading Ease indicates the approximate reading grade level of a text. The formula takes into account sentence length and word length. It is based on a 0-100 scale. A high score means that the text is easier to read.

[4] On a scale of 0 - 17+, the Coleman Liau Index relies on characters and calculates the index based on the number of characters in a word and the number of words in a sentence. The score of the text indicates the US school level a person needs to understand the text.