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EMBEDDED SYSTEMS

Project Final Report

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Embedded Systems

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OBJECTIVE OF THE PROJECT

In this project, it was planned to build an elevator system on the stm32 card using the information explained in the embedded systems course. Due to the use of various sensors and actuators, the system, which was prepared in the simulation environment, became more concrete. As a result, the system was made to work in accordance with the logic of real life by giving various responses to various inputs.

THE DESIGN

The system contains 3 different LEDs for the location information of the elevator, and 3 different buttons have been added for requests by the users for each floor as well. In addition, 2 different LEDs were added for the up and down movement of the elevator and 2 different LEDs for the open and closed movement information of the door. While the added engine provides the movement of the elevator, the elevator movements can be followed with the LCD. An ultrasonic sound wave sensor was added between the door, and the door's movement was regulated accordingly. It is also planned to send a warning sound to inform users when the door is closing. Gas and flame sensor has also been added, in case of any danger, the alarm is given with a buzzer. The algorithm was designed according to the frequency of use of the elevator of the floors. Inputs by the admins over the virtual terminal were set, and floor information and sensor information were delivered to the virtual terminal. Finally, the speed of the elevator was adjusted with the analog input.

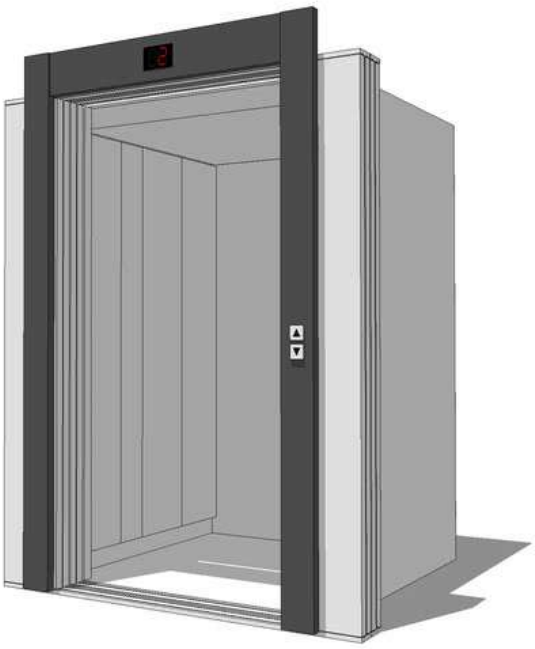

Figure 1. *The idea of the system*

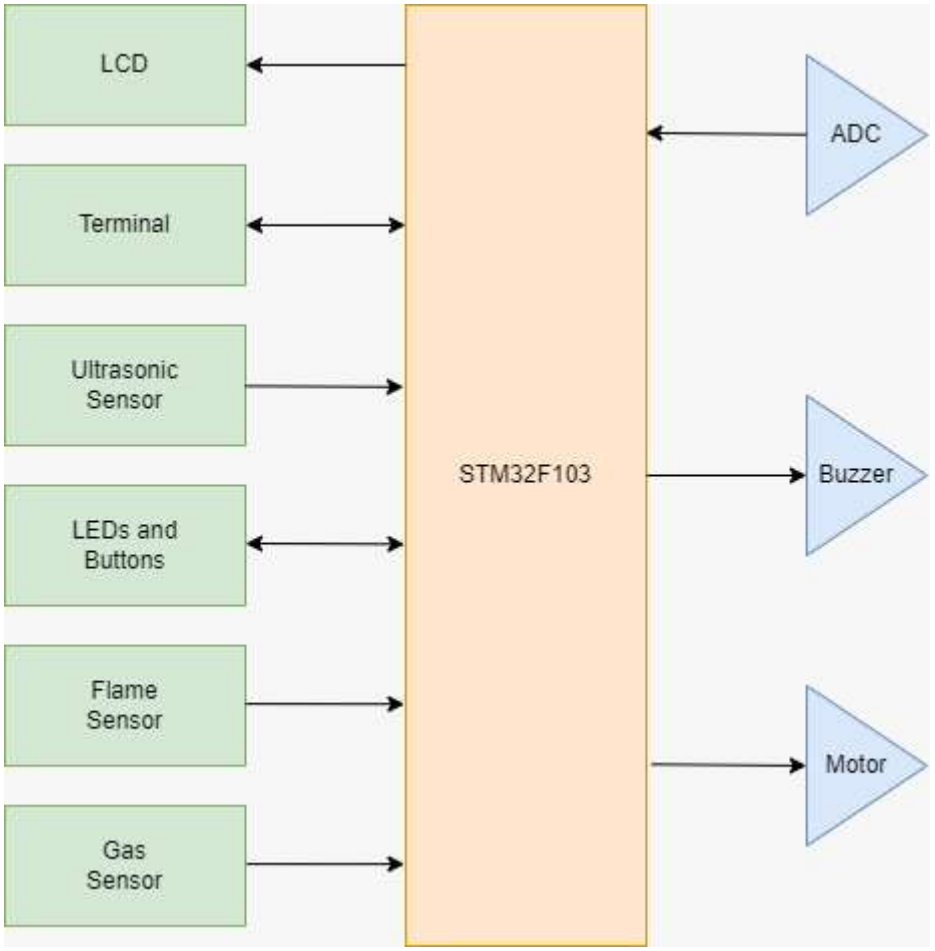

Figure 2. *The design of the system for implementation*

FEATURES OF THE SYSTEM

The general features of the system are as follows: Every user can request an elevator from any floor, regardless of time. The elevator acts by prioritizing the lower floors for simultaneous requests. When the elevator reaches the floor, if there is no request from the priority floor and there is a request on that floor, the door opens and closes after a certain period of time and gives a warning to the user with a buzzer when closing. Door not closing situation may occur depending on the distance sensor (if the distance is smaller than 40 cm). Gas and flame sensor warns the user against any danger. The motor starts when the elevator moves up or down. Users can have information about the elevator with LCD. Admins can have information about elevators and sensors and provide various inputs via a virtual terminal. In order to optimize the use of elevators, an algorithm was designed that takes into account the frequency of elevator use on the floors. When the elevator does not receive any requests, it is positioned on the most used floor recently. With analog input admin can arrange the speed of the elevator.

THE PRICE OF THE ITEMS

STM32F103C6 MCU - 123₺

Buzzer Alarm Module Beeper Speaker Shield STM32 - 46.45₺

Ultrasonic Distance Sensor - HC-SR04 - SEN-15569 - 70₺.

MQ-5 Gas sensor - 550₺.

Flame Sensor - 174.12₺.

LCD Display LM016L 2x16 - 40₺

LEDs - 75₺ for 100pcs

SUMMARY TABLE

Module/Feature	Some of the possible types	

GPIO	• ★ Digital Output
	• ★ Digital Input
	• ★ Other
		• ★ Digital Output
		  ○ Push/Pull x15
		• ★ Digital Input
		  ○ Input x1
		  ○ External Interrupt x5

Communication	• UART ★, • SPI ★ ★, • I2C ★ ★, • CAN ★ ★ ★, Others • Using multiple devices at the same communication bus ★ ★ ★	• UART ★, ○ Interrupt and Timer
Watchdog timer	★	
Interactivity (Leds, buttons, switches, touch etc.)	★ ★	• Leds x9 • 16x2 Display • Buzzer x2 • AND Gate x2 • OR Gate x2

Using sensors	Single ★, few ★ ★, many or advanced one ★ ★ ★ ★	• Sensor x3 types
		  ○ Ultrasonic Wave Sensor HC-SR04
		  ○ Flame Sensor with rising/falling edge interrupt
		  ○ MQ-5 Gas Sensor with rising/falling edge interrupt

Actuators	• Motors	• Motor for elevator

Timers	Systick ★, Advanced-basic Timers ★ ★, RTC alarm ★ ★	• TIM1
		  ○ Periodical Interrrupt Generation
		• TIM2
		  ○ Using the same timer for multiple tasks. A suitable time period was set and delays were applied for

		different tasks using this timer. Moreover, same timer was used for sensor value reading.
Usage of polling	✕✕✕	• We didn't use polling
Usage of Interrupts	No interrupt ✕✕✕, Single ★, few ★★, many with different priorities ★★★	• HAL_TIM_Base_Start_IT • HAL_UART_Receive_IT
Error handling	No error handling ✕, few ★★, full ★★★	• In 3 places: o If the value of the distance sensor is more than 45 or less than 0, the elevator warns admin. (Line 180:Main.c) o Looks if the given floor request on virtual terminal is proper, if not warns on virtual terminal. (Line 552:Main.c) o Error handling for the smart move of elevator
Analog-digital Converter	ADC ★★, DAC ★★	• ADC1
Advanced Things that no code is provided during the course such as DAC, CAN etc.	extra ★★★	• Using of Ultrasonic wave sensor. It requires 3 trigger frequency call to get distance. Besides, we combined that sensor with timer. Therefore, we are calculating the distance more accurately.
Power saving	Sleep - standby - wakeup	

	★★★	
DMA	★★★	• ADC reading with DMA ○ HAL_ADC_Start_DMA
Ethernet-internet-wifi	★★★	
Writing own driver library for a peripheral	★★★★★	
bluetooth	★★★★	
PCB	External electronics design ★★, using a different board ★★★, using MCU unit on your own design without the development board ★★★★★	
Usage of advanced tools e.g., Matlab, CubeAI etc. (Matlab code should run on MCU)	★★★★★	
Real time OS	★★★★★	
IoT	Making it work with: • Node-red, Blynk etc. • Mobile device interaction	

	• Time series database (InfluxDB)	

Table 1. *Summary of the features and modules used in our project*

LIST OF TOOLS AND FEATURES

The list of the used tools and features so far:

GPIO

- Digital Input
- Digital Output
- Interrupt

ADC

- DMA and Periodic Timer

Communication

- USART/UART
- Interrupt and Periodic Timer

Timers

- TIM1
- Periodic interrupt
- TIM2
    - Using the same timer for multiple tasks. A suitable time period was set and delays were applied for different tasks using this timer. Moreover, same timer was used for sensor value reading.

Sensors

- Ultrasonic wave sensor for door distance
- Flame Sensor with rising/falling edge interrupt
- Gas Sensor with rising/falling edge interrupt

Actuators

- Motor for elevator

Displays

- LCD Display LM016L 2x16

Smart Algorithm

- The first, the elevator system acts by prioritizing the lower floors for simultaneous requests. Floor requests are kept in an array and inside the while loop there is a floor request comparison to detect to go up or down according to their priorities. Door opening and closing detection is also arranged according to this algorithm.
- The second, in the final version of the system we have a smart algorithm which analyses last 10 calls for the elevator and door open time, then decides which floor to stop if there is no call for a determined time period. Arrival frequencies of the floors were stored. And after a while, if there is no demand from any floor, we positioned the elevator on the most used floor in the last 10 arrivals.

DESIGN STEPS

Design implantation was added to the project according to the difficulty level. Design steps are listed below:

1- USART receive

2- USART Transmit

3- ADC value transmit on USART

4- Floor request receive on USART

5- Adding floors as LEDs

6- Adding Buttons for floor request

7- Adding door open - close LEDs

8- Adding elevator up-down LEDs

9- Smart algorithm for movement of elevator

10- Adding motor to show that the elevator is working

11- Adding information of elevator on USART

12- Adding LCD screen to observe current floor and elevator movement (up - down - stay)

13- Adding ultrasonic wave sensor to measure the distance

14- Adding buzzer to warn users that door is closing soon

15- Error handling and comments

16- Adding a smart algorithm that considers the arrival frequencies of the floors

17- Adding gas sensor

18- Adding flame sensor

19- Changing IT ADC version to DMA ADC version

CHALLENGES

The biggest challenge encountered while making the project was to implement the timer effectively both for the elevator movement and for the opening and closing of the door. Another challenge was USART implementation, it was hard to receive implementation of floor request over virtual terminal.

SCREENSHOTS

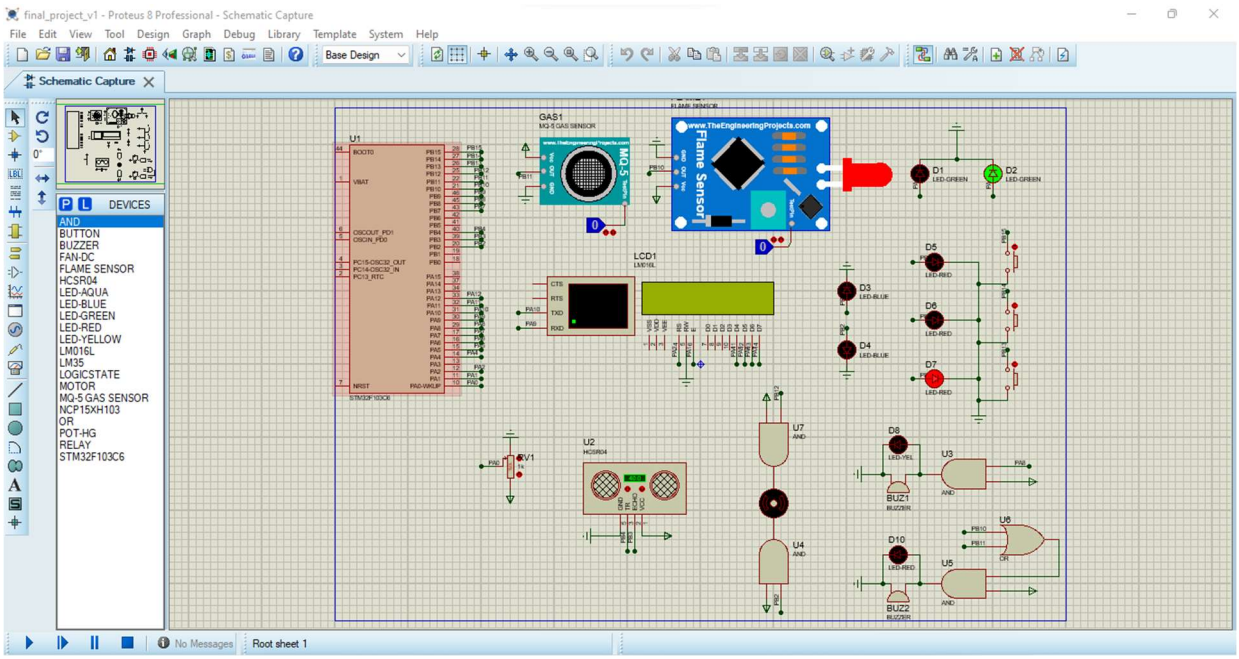

Figure 3. *The overall design of the system on Proteus*

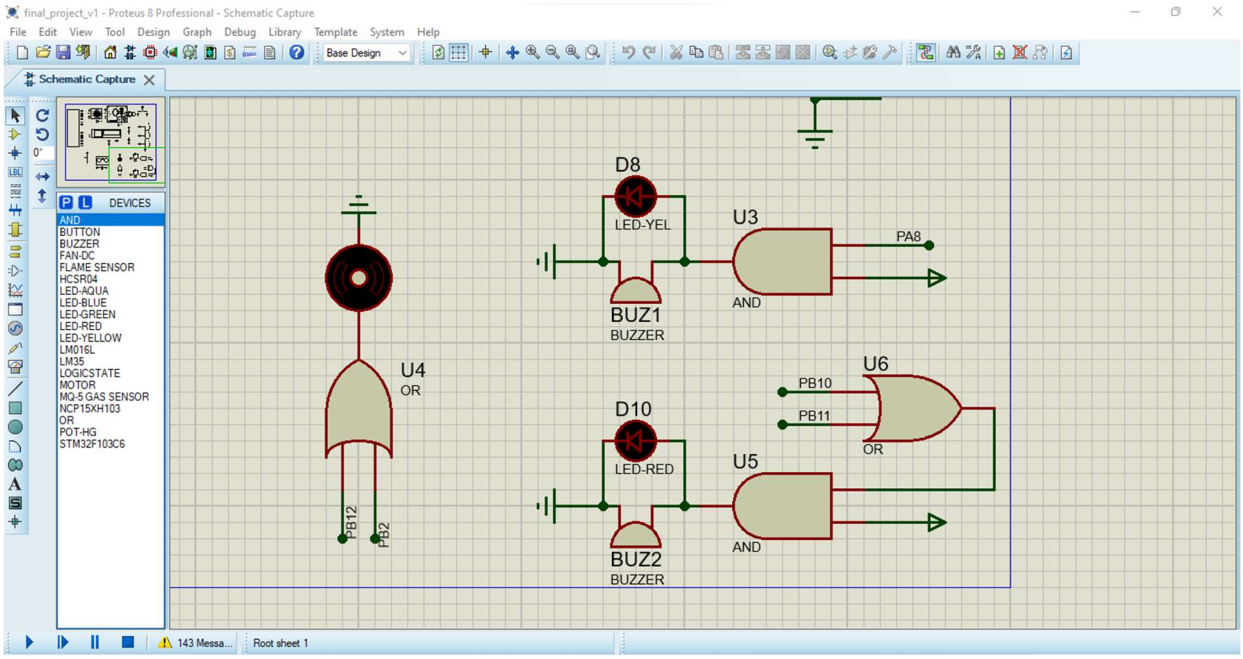

Figure 4. *Buzzer and motor design*

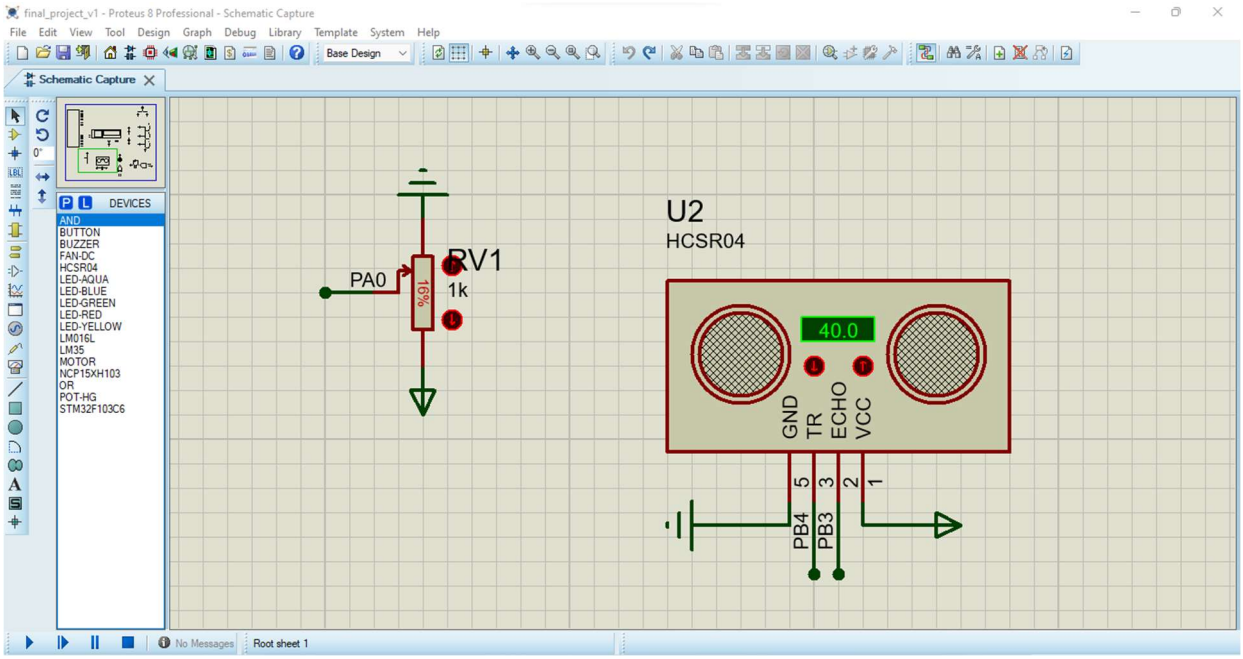

Figure 5. *Ultrasonic wave sensor and ADC converter*

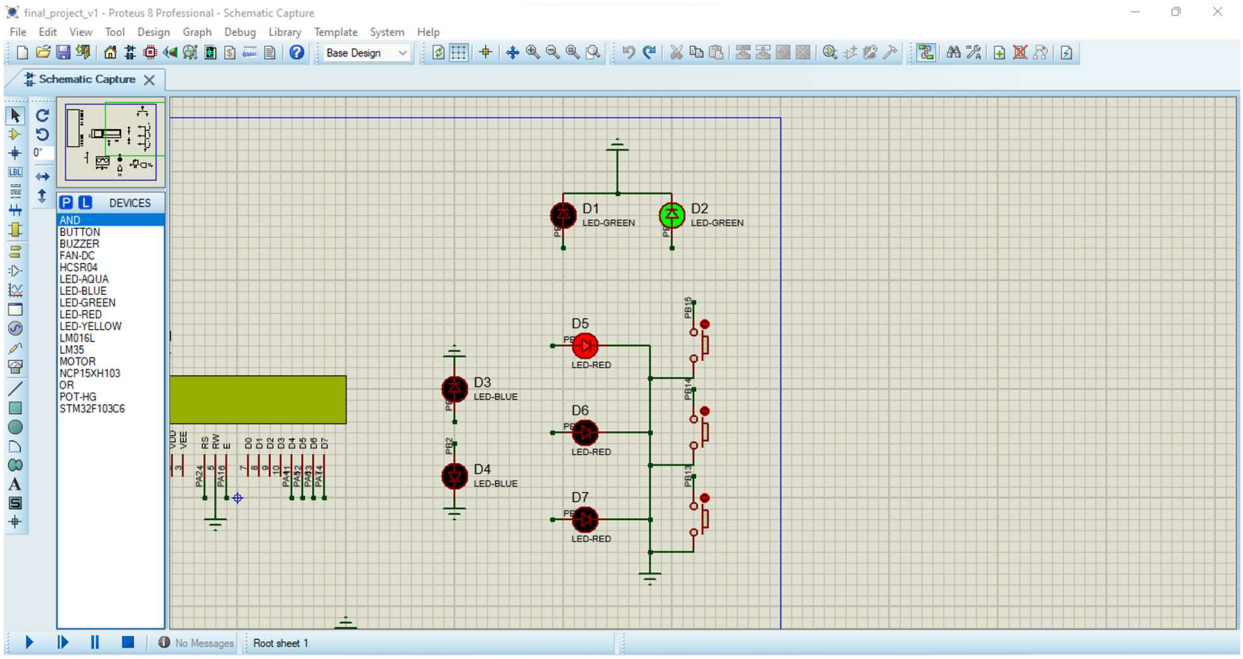

Figure 6. *LEDs to show current floor, up/down movement, door open/close situation and buttons for floor requests*

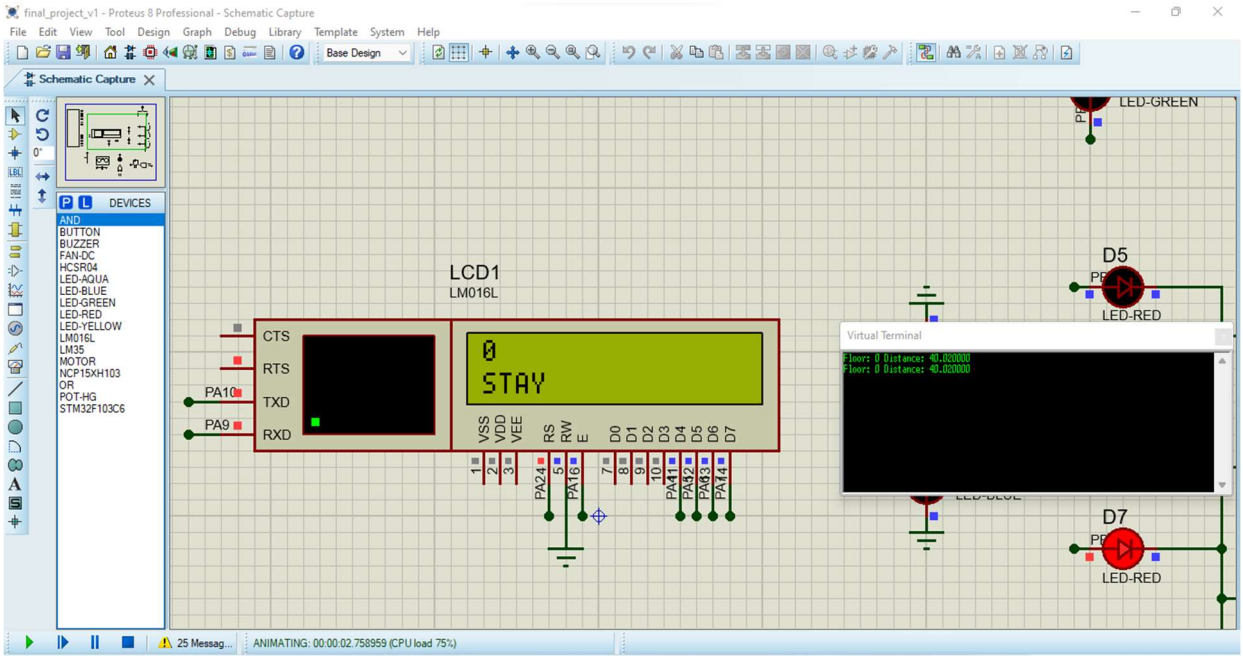

Figure 7. *LCD screen and virtual terminal*

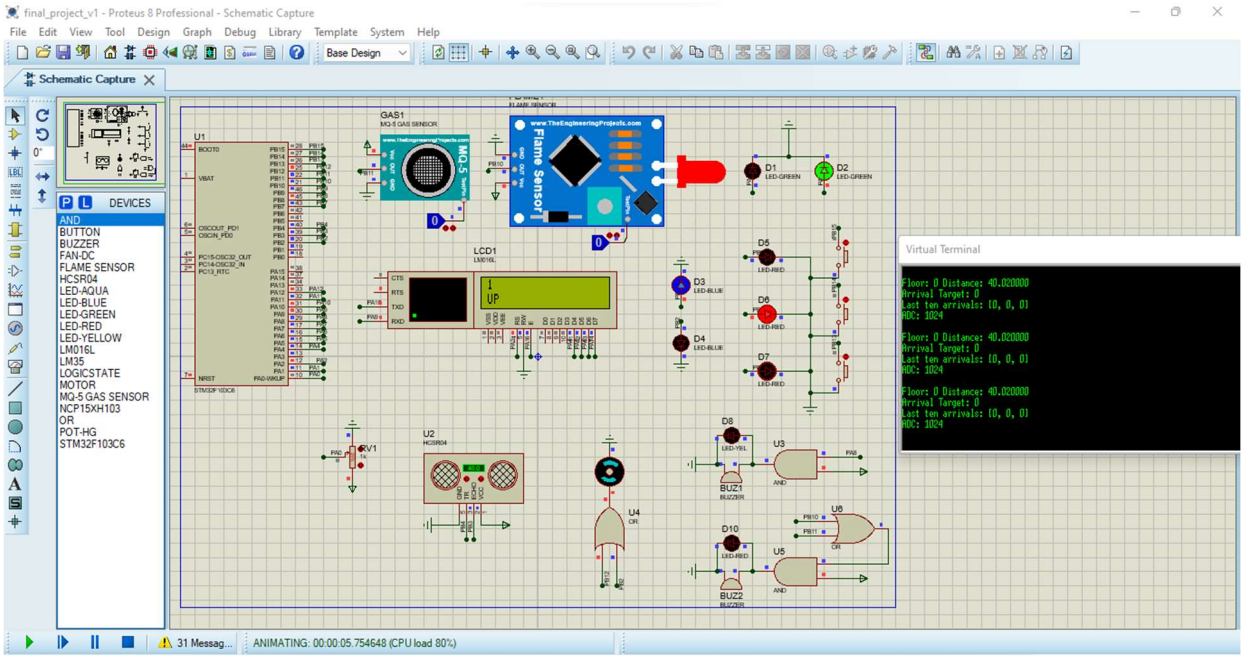

Figure 8. *System while working 1*

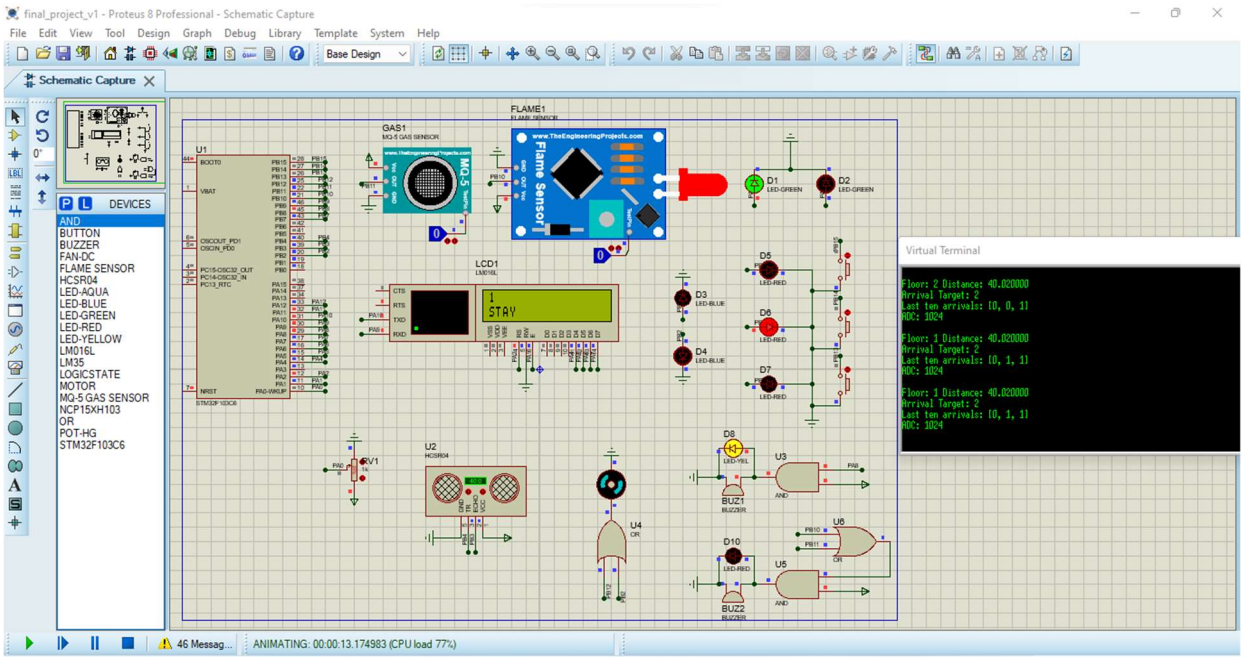

Figure 9. *System while working 2*

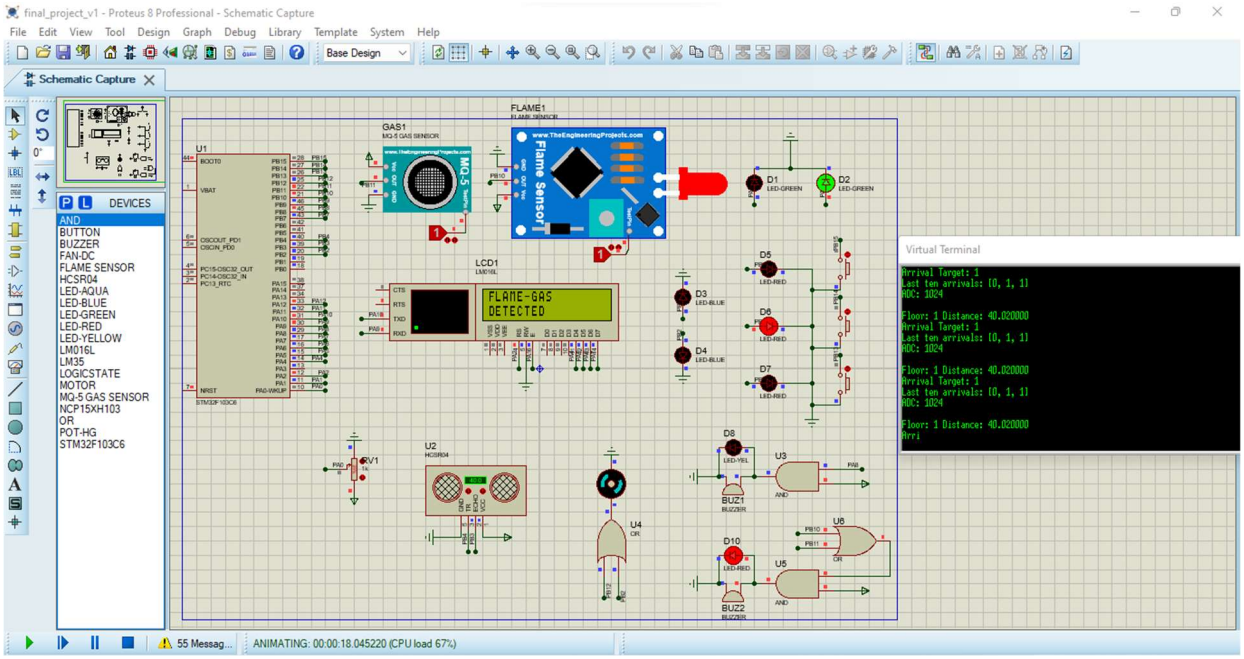

Figure 10. *System while working 3*

LINK

Progress

https://drive.google.com/file/d/1K8cJbYjQHkxzVJPlCSKiz3j1yB_6WlK8/view?usp=sharing

Final

https://drive.google.com/file/d/1zyRLgUWU1XpN7j8fXwx31xC-d8rLiLji/view?usp=sharing