Design and Simulation of Circuits and Embedded Systems

Project Report

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Document History

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Chapter 1. Vehicle Obstacle Detection and Cabin In-Safety Alert System

1.1 Abstract

Vehicles are important in today's fast-paced society. Acquiring a vehicle nowadays is considered a necessity, compared to the past where it was considered a luxury. As more and more vehicles are produced to meet the increasing demands of people and businesses from all corners of the world. Here comes the necessity to provide more and more safety and security features to them. Hence this project aims to design an embedded system for vehicle cabin safety and security by modifying and integrating the existing modules. This monitors the level of the toxic gases such as CO, LPG and alcohol inside the vehicle and provides alert information in the form of alarm during the critical situations. An ultrasonic distance sensor is used to detect the static obstacle in front of the vehicle and the vehicle gets stopped if any obstacle is detected. This may avoid accidents due to collision of vehicles with any static obstacles. A digital sensor is used to detect the status of seatbelt lock so as to prevent the occupant colliding with interior parts of vehicle.

1.2 Motivation

An embedded system designed to make the journey of the passengers inside a vehicle safe and secure with various recently found safety and security measures.

1.3 Defining Features

- Provide safe driving by allowing seatbelts on during driving.
- Driver and passenger experience should be made comfortable inside vehicle by eliminating toxic gases if present. Avoid static object collision while driving the vehicle.
- In reverse motoring mode, vehicle should not bump to objects.
- Easy control of car window glass.

1.4 Research/State of Art

Warning alerts and alarms are other security systems incorporated in the cars and trucks to alert us about various factors like exceeding speed limit or smoke alarms. These are designed to make the passengers aware of crossing the limitations which is important in most of the time and in most cases. In the same way here, an embedded system has been designed to make the journey of the passengers inside a vehicle safe and secure with various recently found safety and security measures.

1.5 Description

Our system is divided into the following subsystems:

- Bonnet System:

  This system focuses to sense any static objects in front of the vehicle to avoid collisions. It Can sense slow-moving or stationary objects when driving at low speeds. Controls are provided even to brake for you to avoid obstacles. Ultrasonic distance sensor are used for this purpose and placed in front of car bonnet.

- Seatbelt System:

  This system checks if the occupant has worn seatbelts through seatbelt lock. There is a digital sensor placed to detect the status of lock whether it is locked or unlock. State lock means seatbelt is worn by occupant and state unlock means seatbelt is not worn by occupant.

- Engine System:

  This system comprises of control to lock ignition engine when a static object or very low speed object is detected very close to vehicle. DC motors are used as car engine and control to lock is received from ultrasonic sensors which are placed Infront of bonnet and trunk. Basically, it works to disconnect car system from ignition whenever an object very close to vehicle is detected.

- Car Cabinet System:

  The following system monitors the level of the toxic gases such as CO, LPG and alcohol inside the vehicle and provides alert information in the form of alarm during the critical situations. Gas sensors like MQ-3, MQ-10 used for the purpose of toxic gas detection is replaced by potentiometer. Alert messages is displayed on 16*2 LCD display. Interrupt signals gets activated when high concentration of toxic gases is detected inside cabinet which directs to open all windows of car so as to escape toxic gases from car environment. Window controls is managed by servo motors. When rising level of toxic gases is found then fan is switched ON controlled by DC motor.

- Trunk system:

  This system uses ultrasonic Sensor is used to detect the static obstacle in front of the vehicle's trunk and the vehicle gets stopped if any obstacle is detected. This may avoid accidents due to collision of vehicles with any static obstacles. Buzzer is used to alert driver. In critical condition vehicle is also stopped.

1.6 Requirements

- <u>High Level Requirements</u>

  1.0) Sense toxic gases like CO, LPG, alcohol within cabinet area.

  2.0) Obstacle sensing and detection.

3.0) Seatbelt Safety assurance

4.0) Controlling car window movements.

- <u>Low Level Requirements</u>

1.0) Sense toxic gases like CO, LPG, alcohol within cabinet area.

1.1 Check if the concentration of toxic gases (CO>20ppm, LPG>1000ppm, alcohol) increases.

1.2) Alert driver and passengers through display screen by mentioning state of the cabinet

1.3) Activate fan in cabinet when mid-level of toxic gas is detected

1.4) Raise windows of car down high level of toxic gas is detected

1.5) Blink LED when fan is switched ON.

2.0) Obstacle sensing and detection.

2.1 Detect any static object found within distance of 50 meters from vehicle's bonnet using ultrasonic sensors.

2.2) Detect any static object found within distance of 50 meters from vehicle's trunk using ultrasonic sensors.

2.3) Use buzzer to alert if any object is found within 50 meters from front bonnet system

2.4) Alert through buzzer if any object is found within 50 meters from back trunk system

2.5) When the object is at 3 meters away from car signals are sent to turn off ignition.

2.6) Calculation of distance using ultrasonic sensor placed in bonnet.

2.7) Calculation of distance using ultrasonic sensor placed in trunk.

3.0) Seatbelt Safety assurance

3.1) Check for seatbelt lock status using digital sensor.

3.2) Turn LED to ON state if seat belt unlocked

3.3) Controlling car window movements.

3.4) Operate window to move the glass upwards using keypad.

3.5) Operate window to move the glass Downwards using keypad.

4.0) Controlling car window movements.

4.1) Move window upwards when “U” button is pressed.

4.2) Move window downwards when “D” button is pressed.

1.7 SWOT Analysis

Fig: SWOT Analysis

1.8 5W'S 1H

Fig. W-H Diagram

1.9 Block Diagram

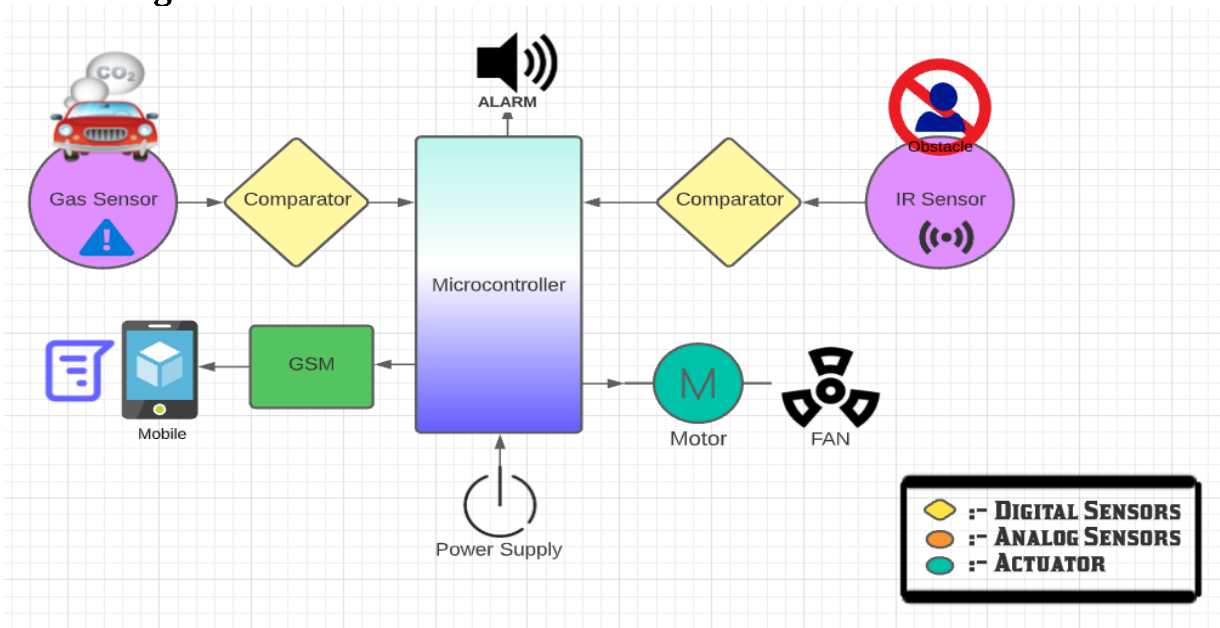


Fig. Block Diagram of system

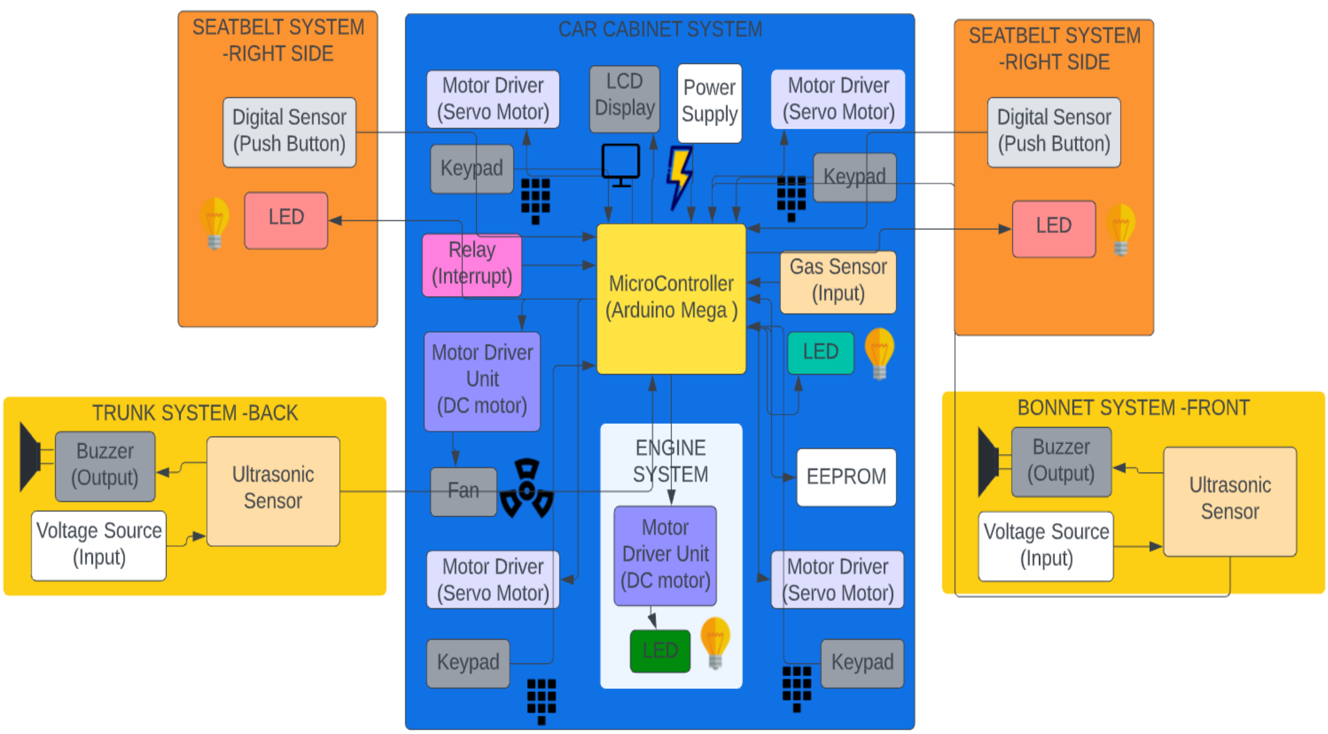


Fig. Block Diagram with system

1.10 Components

1. Microcontroller Board (Arduino Mega):

- It is a microcontroller board based on ATmega2560. It is used as a main block which controls all operations of the system.
- It has 54 digital input/output pins, 16 analog pins, 4 UARTs, 16MhZ crystal oscillator, USB connection, and power jack.

2. Gas Sensor (MQ-7):

- MQ-7 is a highly sensitive gas sensor which is capable of detecting 10 to 10,000 ppm carbon monoxide concentrations in the air.
- It is used for gas leakage detection in home and industry. It is used to detect Alcohol, Benzine, CH4, Hexane, LPG, CO.

3. Ultrasonic Distance Sensor:

- Ultrasonic sensor is an obstacle sensing module used to sense the object such that, accidents due to unwanted parking of the vehicles and collision with trees and other objects especially during the night time could be avoided. In our project we have used two sensors one mounted in front of vehical and the other on the back of vehicle.
- It uses a transducer to send and receive ultrasonic pulses that relay back information about object's proximity.

3. Digital Sensor (Push Button):

- It is a simple switch mechanism to control some process.
- It is used for detection of lock status of seatbelt.

4. Actuators:

- We have used DC motor and servo motors as actuators where DC motor is used for motoring operation of fan which act as an ignition system of vehicle. While servo motor is used for movement of car window in direction up and down.

5. Binary Actuator:

- Relay is used to trigger external interrupts which is produced when gas concentration detected is greater than 700 ppm. (assumed)

6. LCD Display:

- It is used to give alert information of gas sensor.

7. Buzzer:

- It is an audio signaling device.
- It is used to alert of object collision through audio signal.

8. Keypad:

- It is used to take input from passengers to operate car window movement like up or down.

1.11 System Architecture

1.11.1 Behavioral Diagram

- Obstacle detection and safety System:

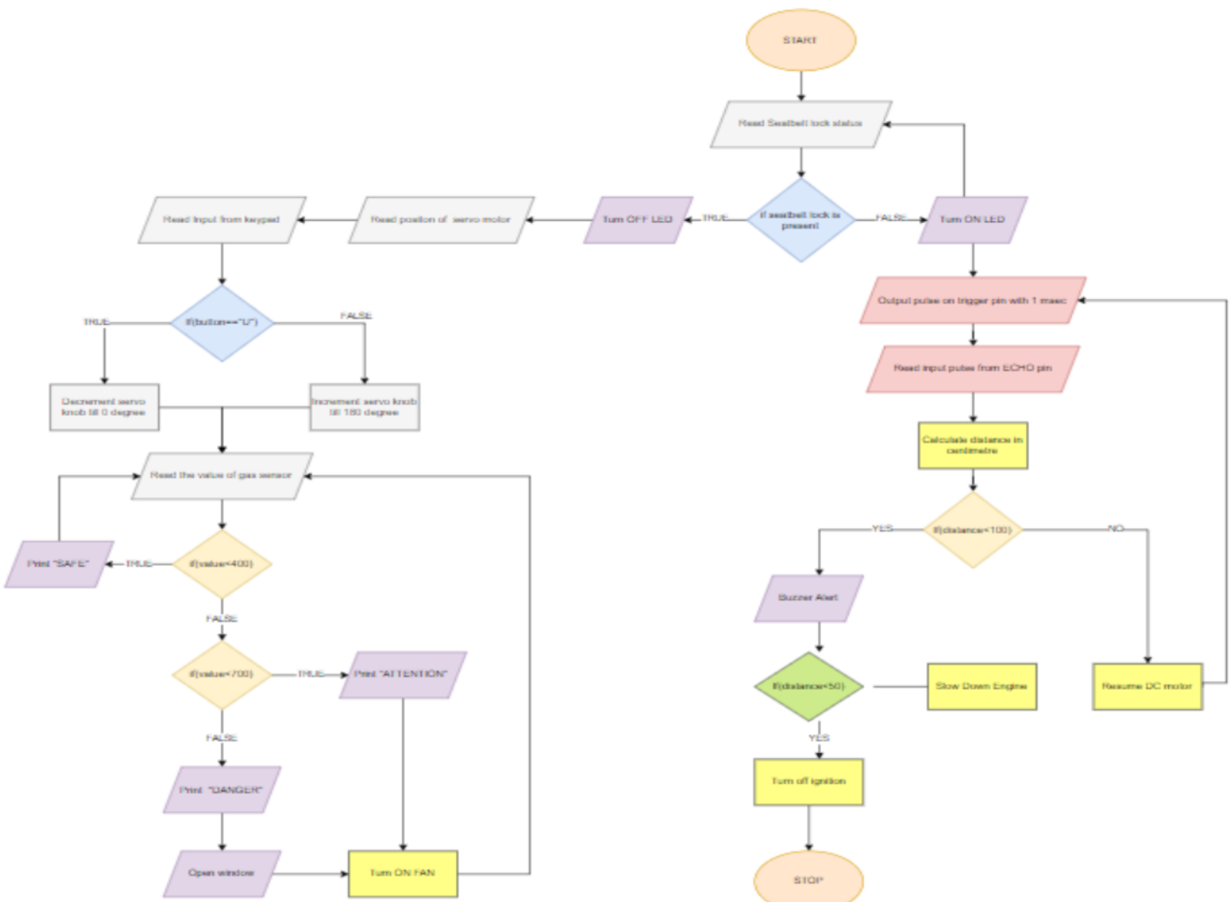


Fig. Flowchart of Whole system

- Obstacle Detection Sub-System:

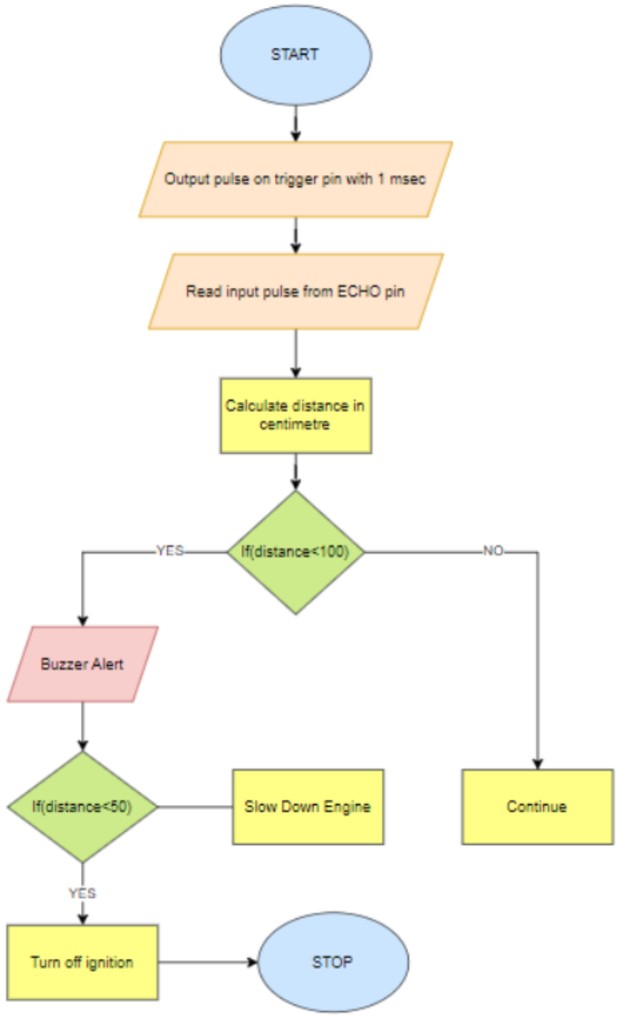


Fig. Flowchart of Sub-System

- Seatbelt Detection Sub-System:

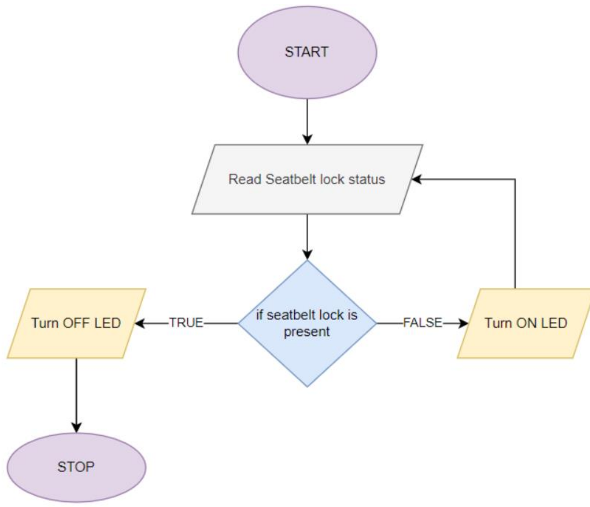


Fig. Flowchart of Sub-System

- Car window Sub-System:

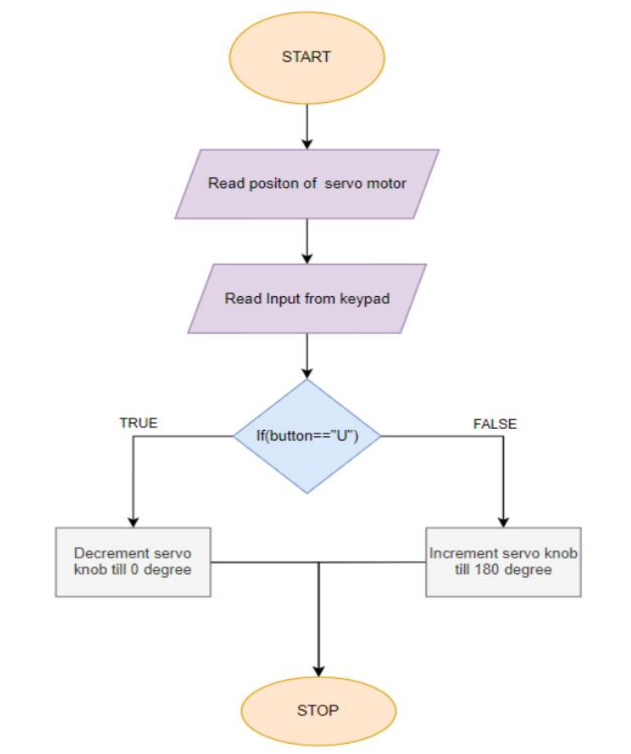


Fig. Flowchart of Sub-System

- Cabinet Sub-System:

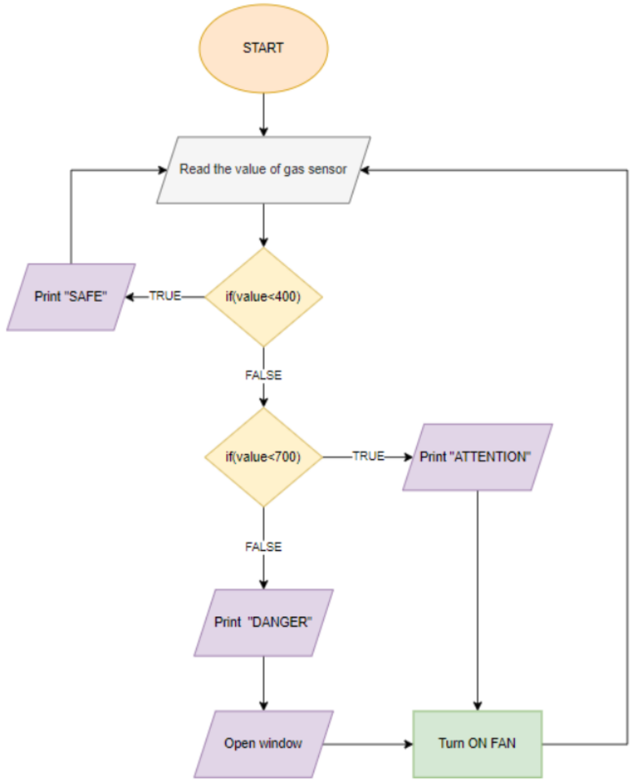


Fig. Flowchart of Sub-System

11.1.2 Structural Diagram

- Seatbelt Detection Sub-System:

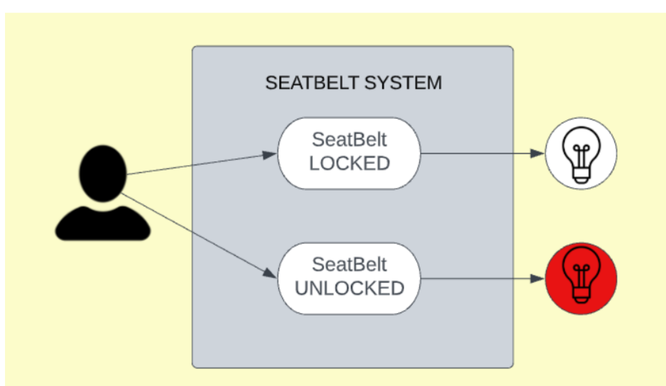


Fig. UML Case Diagram

- Obstacle Detection Sub-System:

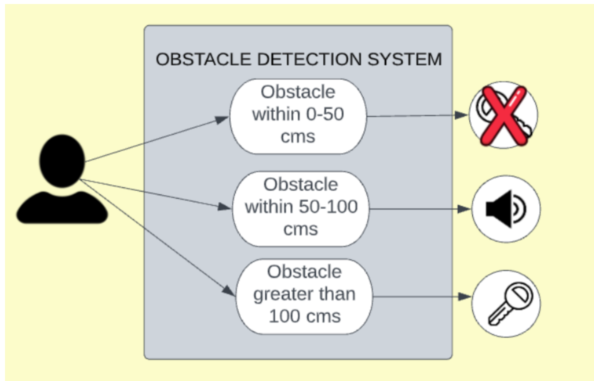


Fig. UML Case Diagram

- Cabinet Sub-System:

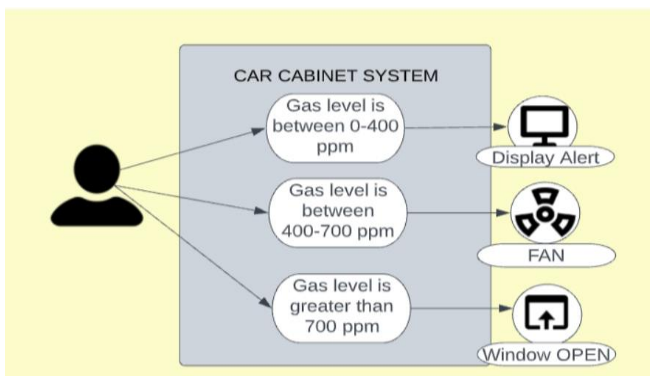


Fig. UML Case Diagram

11.1.3 Component Diagram

- Seatbelt Detection Sub-System:

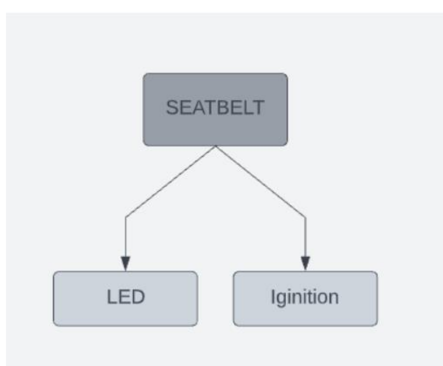


Fig. Component Diagram of sub-system

- Obstacle Avoidance Sub-System:

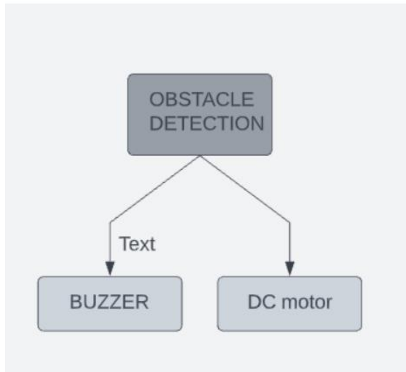


Fig. Component Diagram of sub-system

- Cabinet Sub-System:

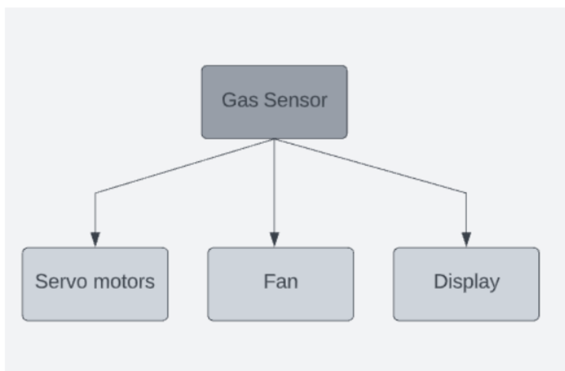


Fig. Component Diagram of sub-system

1.12 Test Plan and Output

- High Level Test Plan

Test ID	Description	Input	Expected Output	Actual Output	Status
01	Check Front Right Seatbelt lock status	Push button1 pressed	LED1 OFF	LED1 OFF	SUCCESS
02	Check Front Right Seatbelt unlock status	Push button1 should not be pressed	LED1 ON	LED1 ON	SUCCESS
03	Check Front Left Seatbelt lock status	Push button2 pressed	LED2 OFF	LED2 OFF	SUCCESS
04	Check Front Left Seatbelt unlock status	Push button2 should not be pressed	LED2 ON	LED2 ON	SUCCESS
05	Check Back Right Seatbelt lock status	Push button3 pressed	LED3 OFF	LED3 OFF	SUCCESS
06	Check Back Right Seatbelt unlock status	Push button3 should not be pressed	LED3 ON	LED3 ON	SUCCESS
07	Check Back Left Seatbelt lock status	Push button4 pressed	LED4 OFF	LED4 OFF	SUCCESS
08	Check Back Left Seatbelt unlock status	Push button4 should not be pressed	LED4 ON	LED4 ON	SUCCESS

Test ID	Description	Input	Expected Output	Actual Output	Status
01	Ultrasonic sensor 1	Voltage source = 4V	No beep sound	No beep sound	SUCCESS
02	Ultrasonic sensor 1	Voltage source = 3V	No beep sound	No beep sound	SUCCESS
03	Ultrasonic sensor 1	Voltage source = 2.5V	No beep sound	No beep sound	SUCCESS
04	Ultrasonic sensor 1	Voltage source = 1V	No beep sound	No beep sound	SUCCESS
05	Ultrasonic sensor 1	Voltage source = 0.9V	No beep sound	No beep sound	SUCCESS
06	Ultrasonic sensor 1	Voltage source = 0.7V	No beep sound	No beep sound	SUCCESS
07	Ultrasonic sensor 1	Voltage source = 0.55	No beep sound	No beep sound	SUCCESS
08	Ultrasonic sensor 1	Voltage source = 0.44V	Beep sound	Beep sound	SUCCESS
09	Ultrasonic sensor 1	Voltage source = 0.04V	Beep sound	Beep sound	SUCCESS
10	Ultrasonic sensor 1	Voltage source = 0.38V	Beep sound	Beep sound	SUCCESS
11	Ultrasonic sensor 1	Voltage source = 0.22V	Beep sound	Beep sound	SUCCESS

Test ID	Description	Input	Expected Output	Actual Output	Status
01	Ultrasonic sensor 2	Voltage source = 4.5V	No beep sound	No beep sound	SUCCESS
02	Ultrasonic sensor 2	Voltage source = 3.1V	No beep sound	No beep sound	SUCCESS
03	Ultrasonic sensor 2	Voltage source = 2.5V	No beep sound	No beep sound	SUCCESS
04	Ultrasonic sensor 2	Voltage source = 1.1V	No beep sound	No beep sound	SUCCESS
05	Ultrasonic sensor 2	Voltage source = 0.98V	No beep sound	No beep sound	SUCCESS
06	Ultrasonic sensor 2	Voltage source = 0.78V	No beep sound	No beep sound	SUCCESS
07	Ultrasonic sensor 2	Voltage source = 0.515	No beep sound	No beep sound	SUCCESS
08	Ultrasonic sensor 2	Voltage source = 0.414V	Beep sound	Beep sound	SUCCESS
09	Ultrasonic sensor 2	Voltage source = 0.104V	Beep sound	Beep sound	SUCCESS
10	Ultrasonic sensor 2	Voltage source = 0.318V	Beep sound	Beep sound	SUCCESS
11	Ultrasonic sensor 2	Voltage source = 0.212V	Beep sound	Beep sound	SUCCESS

Test ID	Description	Input	Expected Output	Actual Output	Status
01	Gas sensor	Potentiometer = 110	SAFE	SAFE	SUCCESS
02	Gas sensor	Potentiometer = 220	SAFE	SAFE	SUCCESS
03	Gas sensor	Potentiometer = 330	SAFE	SAFE	SUCCESS
04	Gas sensor	Potentiometer = 440	ATTENTION	ATTENTION	SUCCESS
05	Gas sensor	Potentiometer = 550	ATTENTION	ATTENTION	SUCCESS
06	Gas sensor	Potentiometer = 660	ATTENTION	ATTENTION	SUCCESS
07	Gas sensor	Potentiometer = 770	DANGER	DANGER	SUCCESS
08	Gas sensor	Potentiometer = 880	DANGER	DANGER	SUCCESS
09	Gas sensor	Potentiometer = 990	DANGER	DANGER	SUCCESS

- <u>Low Level Test Plan</u>

Test ID	Description	Input	Expected Output	Actual Output	Status
01	Servo motor1 Keypad Commands	"U"	Servo motor knob should move upward	Servo knob turned up	SUCCESS
02	Servo motor1 Keypad Commands	"D"	Servo motor knob should move downward	Servo knob turned down	SUCCESS
03	Servo motor2 Keypad Commands	"U"	Servo motor knob should move upward	Servo knob turned up	SUCCESS
04	Servo motor2 Keypad Commands	"D"	Servo motor knob should move downward	Servo knob turned down	SUCCESS
05	Servo motor3 Keypad Commands	"U"	Servo motor knob should move upward	Servo knob turned up	SUCCESS
06	Servo motor3 Keypad Commands	"D"	Servo motor knob should move downward	Servo knob turned down	SUCCESS
07	Servo motor4 Keypad Commands	"U"	Servo motor knob should move upward	Servo knob turned up	SUCCESS
08	Servo motor4 Keypad Commands	"D"	Servo motor knob should move downward	Servo knob turned down	SUCCESS

Test ID	Description	Input	Expected Output	Actual Output	Status
01	FAN	Potentiometer = 110	DC motor should not run	DC motor should not run	SUCCESS
02	FAN	Potentiometer = 290	DC motor should not run	DC motor should not run	SUCCESS
03	FAN	Potentiometer = 370	DC motor should not run	DC motor should not run	SUCCESS
04	FAN	Potentiometer = 450	DC motor should run	DC motor should run	SUCCESS
05	FAN	Potentiometer = 520	DC motor should run	DC motor should run	SUCCESS
06	FAN	Potentiometer = 700	DC motor should run	DC motor should run	SUCCESS
07	FAN	Potentiometer = 850	DC motor should run	DC motor should run	SUCCESS

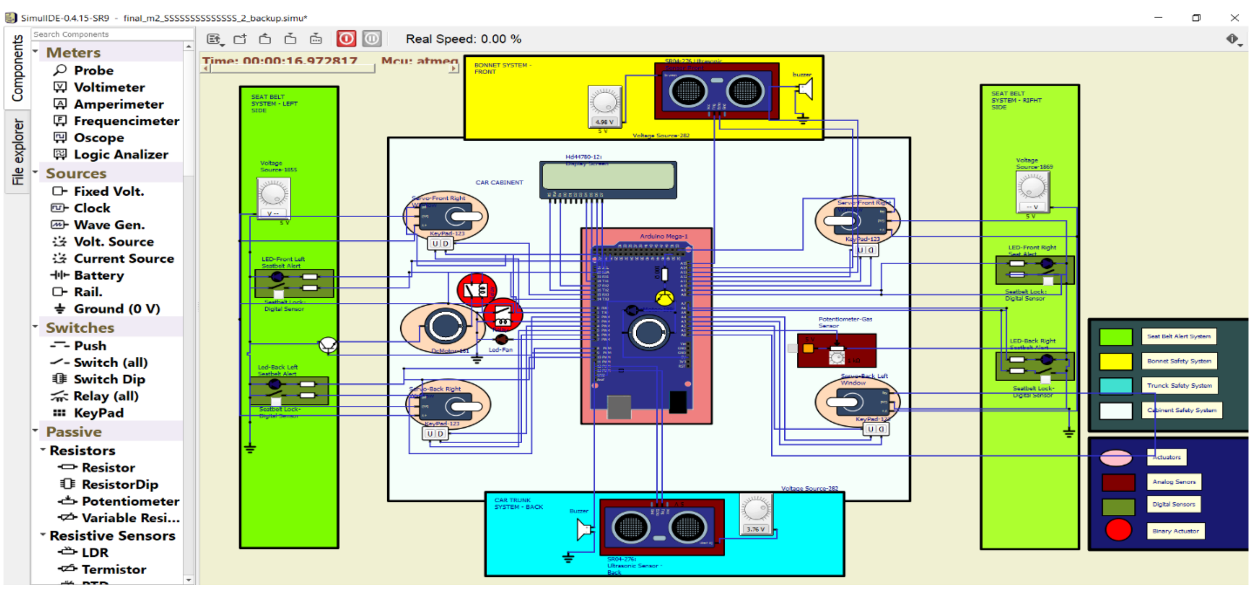
Test ID	Description	Input	Expected Output	Actual Output	Status
01	Engine Check	Voltage source = 4V	DC motor should run	DC motor should run	SUCCESS
02	Engine Check	Voltage source = 5V	DC motor should run	DC motor should run	SUCCESS
03	Engine Check	Voltage source = 3V	DC motor should run	DC motor should run	SUCCESS
04	Engine Check	Voltage source = 0.5V	DC motor should run	DC motor should run	SUCCESS
05	Engine Check	Voltage source = 0.42V	DC motor should run	DC motor should run	SUCCESS
06	Engine Check	Voltage source = 0.35V	DC motor should run	DC motor should run	SUCCESS
07	Engine Check	Voltage source = 0.28V	DC motor should not run	DC motor should not run	SUCCESS
08	Engine Check	Voltage source = 0.15V	DC motor should not run	DC motor should not run	SUCCESS
09	Engine Check	Voltage source = 0.1V	DC motor should not run	DC motor should not run	SUCCESS

1.13 Applications

- Automobile industry.
- Factories for gas leakage detection.
- Handicappers can use obstacle detection module.
- Seatbelt lock detection can be extensively used in four-wheeler vehicles.

1.14 Output

1.14.1 Simulation Circuit

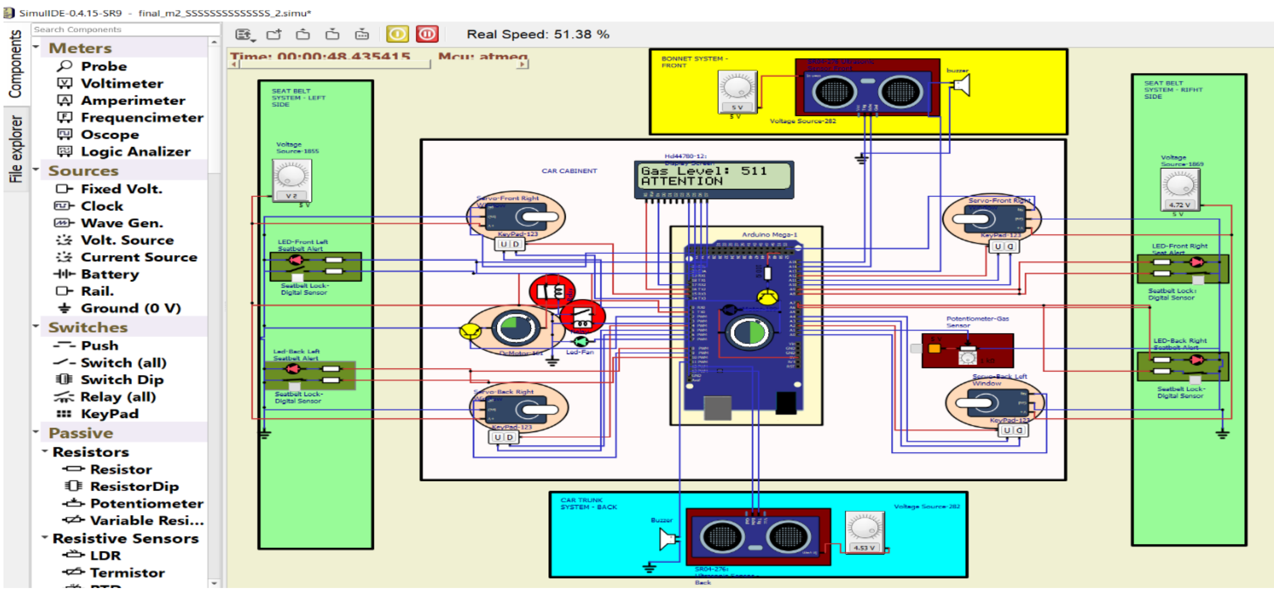


Fig, Simulation Circuit

1.14.2 Simulation Output

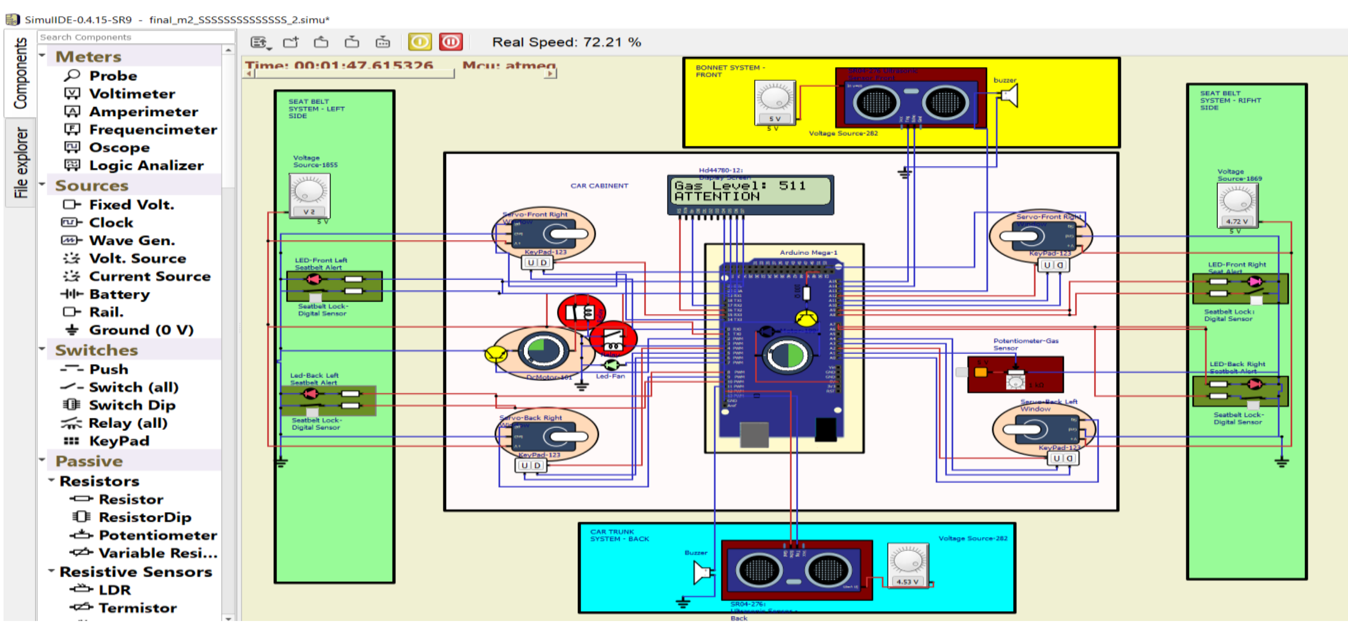
- Seatbelt Detection Sub-System

When occupant in front left seat does not lock seatbelt. Then his seat associated LED blinks



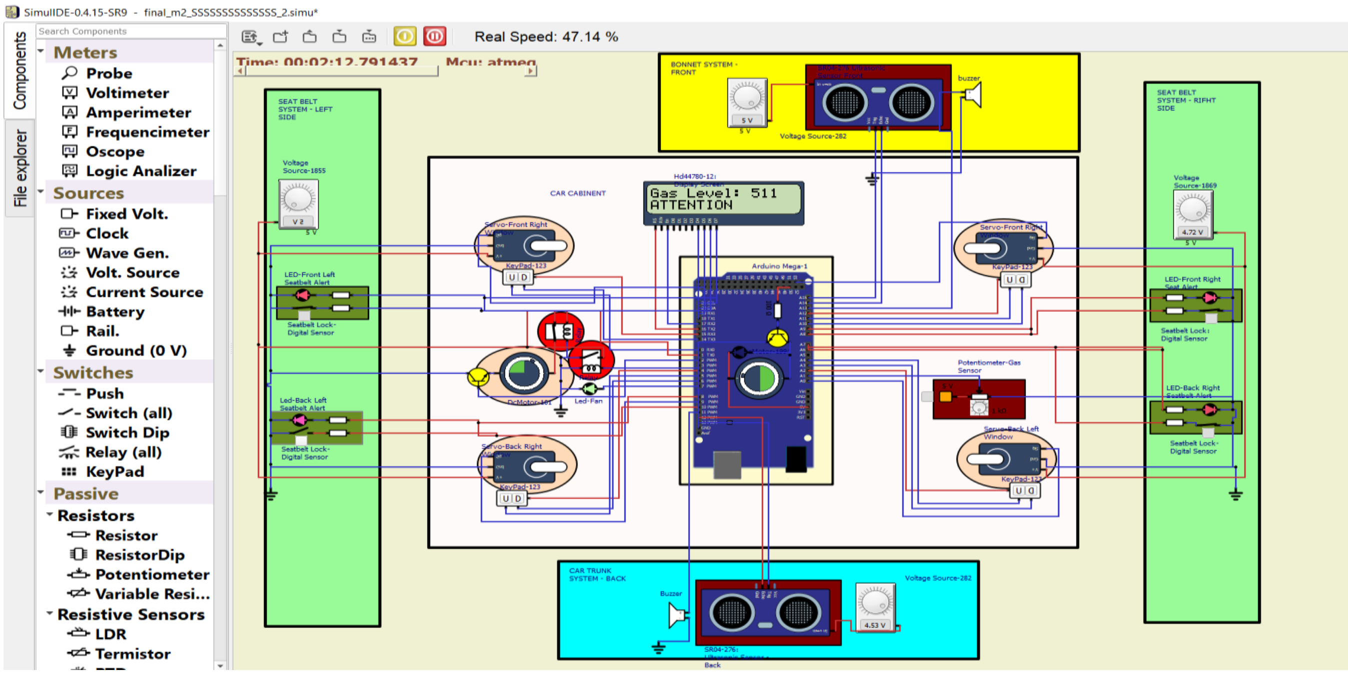
Fig, Simulation Circuit

- When occupant in front right seat does not lock seatbelt. Then his seat associated LED blinks.



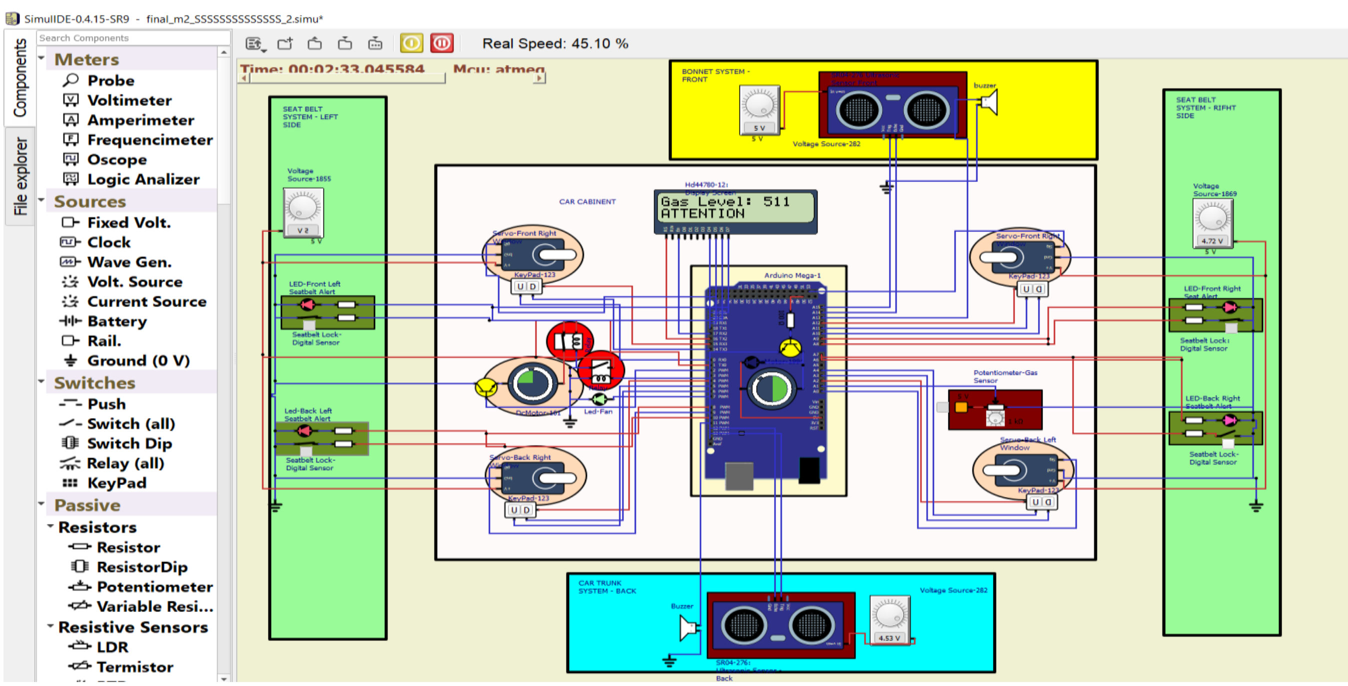
Fig, Simulation Circuit

- When occupant in back left seat does not lock seatbelt. Then his seat associated LED blinks.



Fig, Simulation Circuit

- When occupant in back right seat does not lock seatbelt. Then his seat associated LED blinks.



Fig, Simulation Circuit

- Cabinet Safety System

When level of gases present inside cabinet is within range (0-400)ppm. OBSERVATION:

- Display message "SAFE"
- Fan is turned OFF.
- Window position (servo motors) is unaffected.

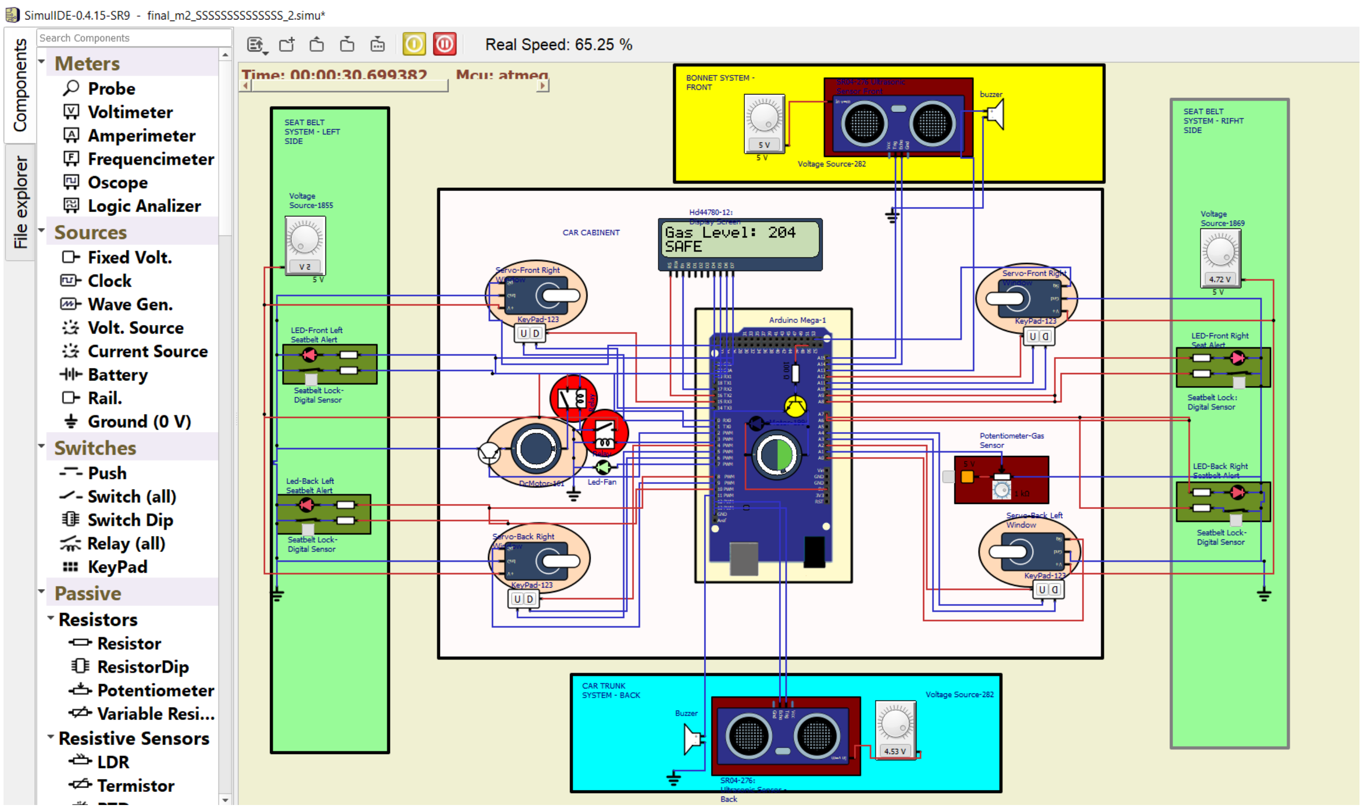


Fig. Simulation Circuit

When level of gases present inside cabinet is within range (400-700) ppm. OBSERVATION:

- Display message "ATTENTION"
- Fan is turned ON.
- Window position (servo motors) is unaffected.

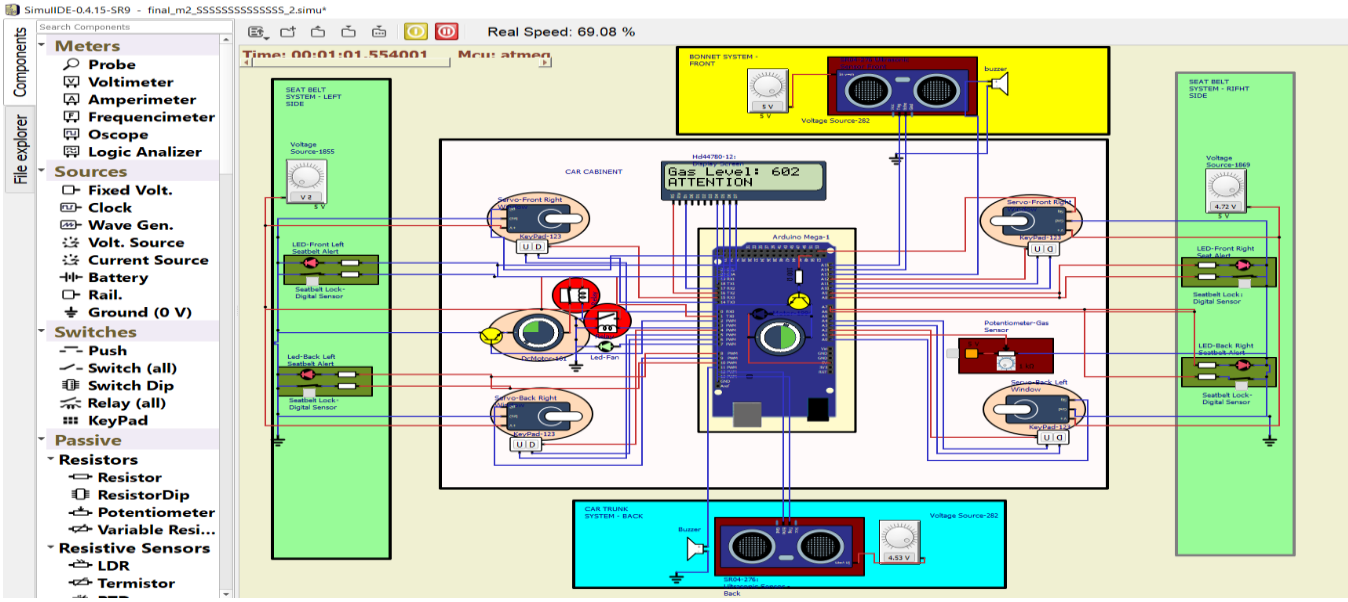


Fig. Simulation Window

When level of gases present inside cabinet is greater than 700 ppm. OBSERVATION:

- Display message "DANGER"
- Fan is turned ON.
- Window position (servo motors) is affected. They are opened completely.

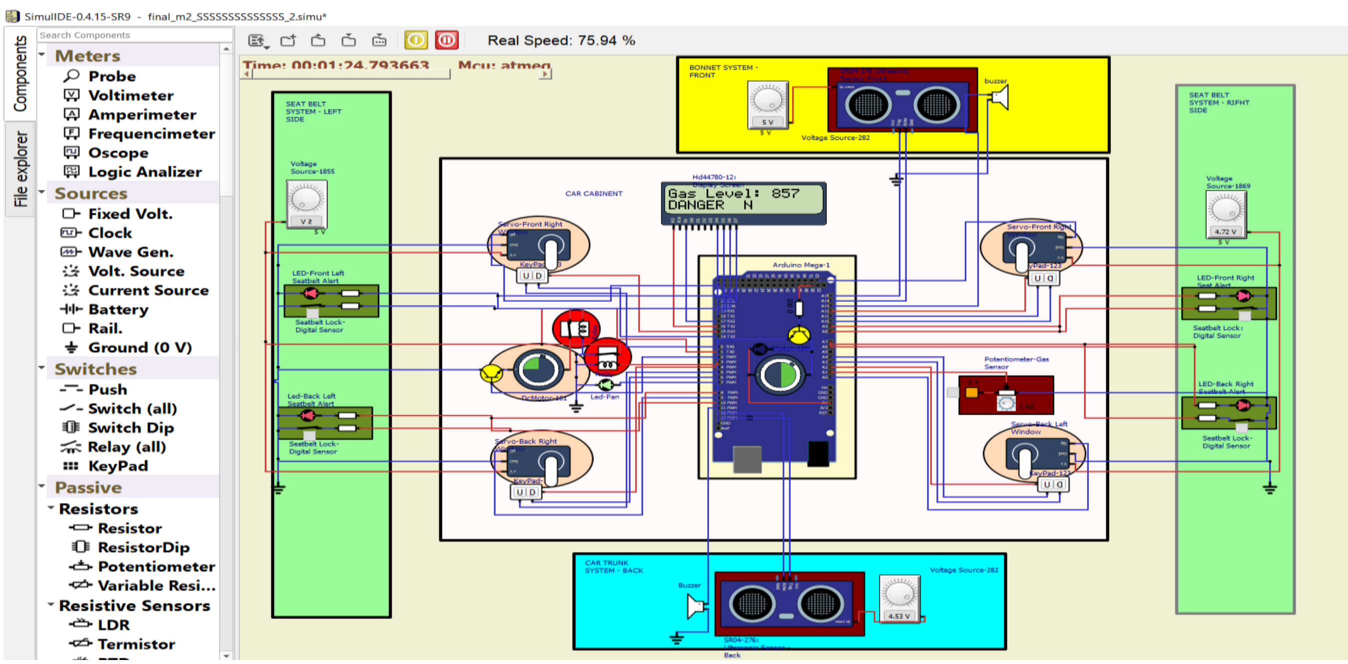


Fig. Simulation Window

When "U" button of keypad is pressed. OBSERVATION:

- Servo motor knob if lifted towards up.

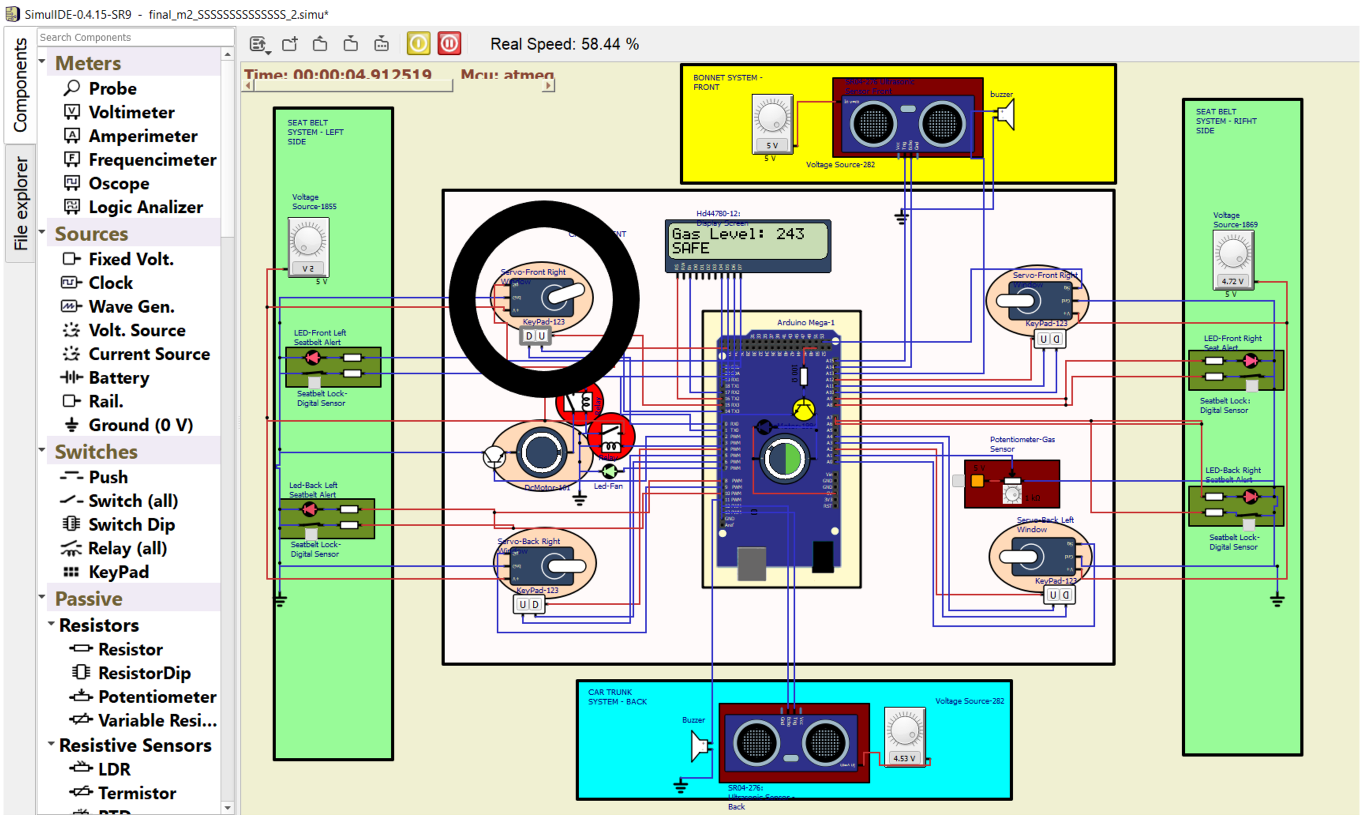


Fig. Simulation Window

2.15 References

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