SSRG International Journal of Mechanical Engineering
ISSN: 2348 – 8360 /doi:10.14445/23488360/IJME-V8I7P101

Volume 8 Issue 7, 1-9, July, 2021

Experimental Results for Designing and Building a New Intelligent System for Fire Alarm and Extinguishing in Automotives

Esmaeil Mirmahdi [*1], Mostafa Esmaeili[2], Daniyal Rahimi[2], Seyed Ali Mousavi[2]

[1]*Lecturer and Professor, Department of Mechanical Engineering, Technical and Vocational University (TVU), Tehran, Iran*
[2]*Undergraduate Student, Department of Mechanical Engineering, Technical and Vocational University (TVU), Tehran, Iran*

Received Date: 05 June 2021
Revised Date: 10 July 2021
Accepted Date: 20 July 2021

Abstract
Unwanted automotive fires cause annual human, financial and environmental damage. Automotive fires can be caused by accidents, technical problems of the automotive system, design defects, overheating of the engine due to improper cooling, fuel leaks, automotive electronic system connections, non-observance of safety issues, and other factors. There are solutions to prevent this from happening, including proper and safe design, automotive insulation, reducing the ignition of gases and fuels in the engine compartment and fuel tank, using new fire extinguishing systems, and observing safety measures. The purpose of this article is to provide an automatic and intelligent warning and extinguishing system to reduce the damage caused by this accident. In this way, in the first place, after sensing the fire components by the sensors, the driver and occupants inside the cabin are informed of the fire hazard to get out of the automotive. Another suggestion in this article is to set up a communication system with the driver's mobile phone and notify him of the fire. In the next step, the system works to extinguish and extinguish the fire and inhibits it by spraying fire-retardant materials such as water.

Keywords: *Fire Extinguishing, Fire Alarm, Smoke and Fire and Gas Detection Sensors, Safety, Mobile Information*

I. Introduction

Fire is an important thing that can happen to vehicles, passenger automobiles, buses, trucks, and planes, etc., but the most important issue is how to prevent loss of life and property. According to the National Fire Protection Association, an American trade union (NFPA) that blames technical defects in automotive mechanical and electronic equipment, engine compartments, and fuel tanks are more likely to catch fire [1]. More than 2,000 vehicles are damaged by unintentional fires every day [2]. Figure 1 shows vehicle fires due to technical defects in mechanical and electronic factors. Fire detection is performed by an infrared receiver and an MQ-2 smoke sensor [3]. In general, the automatic alarm and extinguishing system includes the following components and components:

- **Sensors:** Sensors detect external values such as smoke, sudden temperature rise, leakage of gases such as carbon monoxide (co), carbon dioxide (CO2), methane (CH), light fuels such as liquefied petroleum gas, city gas, etc. [4-5] A feature of this system is that

  After observing and detecting the first signs of fire in the automotive, it calls the numbers that have already been registered on it and reports this dangerous accident.
- **Microcontrollers:** Microcontrollers receive relevant information from sensors and issue commands accordingly [6]. In this system, the microcontroller notifies the driver of the danger after receiving the voltage of the sensors, which means fire, with actuators such as an audible alarm device and the fire alarm light on the back of the amp or automotive screen. Also, by sending commands to stop the flow of gasoline to the pump, as well as by sending a signal, the pump starts the anti-ignition material (water), and the water extinguishes the fire by passing through the pipes connecting to the installed nozzles. In the engine compartment, in the event of an automotive fire, the lives of people were at risk because the automotive doors did not open, and one of the new suggestions in this article is to prevent the doors from locking [7-8].

Fig 1. Images of automotive fires

II. Smoke and fire detection sensors

In general, fire detection sensors include smoke detectors, flame detection sensors, heat detection sensors, and gas detection sensors.

There are two types of smoke detectors:

- Ionization smoke sensor: This type of detector has a high ability to detect smoke from the fire. Types of ionization detectors consist of an alpha particle that produces a radioactive source consisting of a smoke chamber and a charged detector plate. The alpha source conducts the air in the ionized smoke chamber. When the smoke particles enter the smoke chamber, they attach themselves to the ionized air molecules. The reduced media in the chamber sends a signal to the controller that a fire is occurring.
- Photoelectric smoke sensor: This sensor detects smoke using the principles of light blocking or light scattering. The ability of these sensors to detect smoke from fires is best used in fires that produce large particles in the combustion process, but this sensor depends on the light source. If the light is dimmed, it detects that there is smoke in the environment.
- Flame Detector Sensor: Generally works according to the different spectrums of flame created by the combustion of various combustible materials. These sensors are divided into three categories according to the spectrum and wavelength: ultraviolet wavelength, infrared wavelength, or a combination of both. These sensors operate very quickly and are used in areas where there is a possibility of repeated fires or explosions.
- Thermal Detector Sensor: Another type of fire sensor and detector is a thermal detector sensor that senses an increase in temperature in the environment and is unable to detect the chemical combustion process. They should not be used in environments where heat is normal. An example of such a detector is the LHD detector, also known as a cable detector. Uses: Fire is used in special conditions such as protection of transformers, oil tanks, conveyor belts, various types of engines, etc.
- Gas detection sensor: A gas detector is used to detect toxic gases, flammable and explosive gases, oxidizing gases, and hazardous gases. Figure 2 shows an example of a gas (MQ) type sensor that uses a small internal heater with an electrochemical sensor. These sensors are highly sensitive to a wide range, such as carbon monoxide (CO), methane (CH4), liquefied petroleum gas (LPG), city gas (CNG), and smoke.

Fig 2. Gas detection sensor

III. Microcontroller

A microcontroller is an IC chip that takes information from sensors and processes it according to the programming done on it, giving the necessary command to other devices. In microcontrollers, RAM, ROM, and EEPROM are embedded. Figure 3 shows an example of a microcontroller chip. Microcontrollers are small but versatile devices with very fast performance and are very cheap compared to other computers. Types of microcontrollers are arm microcontrollers, atx mega microcontrollers, plc microcontrollers, AVR microcontrollers, etc. In this Automotive fire extinguishing system, the microcontroller receives the required information from the smoke, fire, and gas sensors and, after processing the information, issues commands to control the actuators; These include warning the driver through the automotive display or turning on the fire alarm light behind the amp, sounding the alarm like a loud siren, disabling the fuel pump to prevent fuel from reaching the engine, and preventing ignition and explosion. Vehicle, activate the fire extinguisher and water flow pump to extinguish the fire.

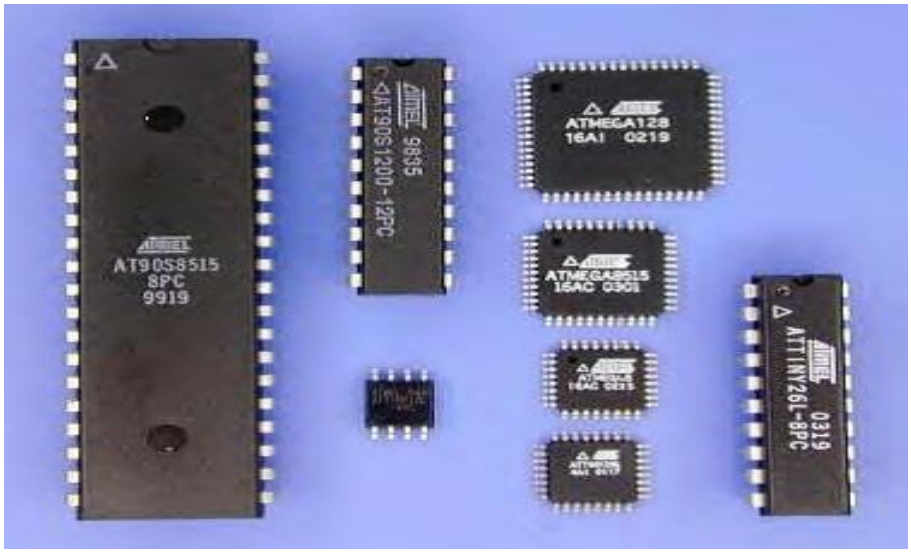

Fig 3. An example of a microcontroller chip

IV. Actuators

The actuators used in the automotive fire extinguishing system include the following, for which a new design has been made.

A. Announcement warning in the form of sound

In this article, according to the new design that has been done for alarm sound notification, it takes the command of activating itself from the microcontroller and receives the current from its special relay, and announces the fire loudly.

The microcontroller commands again, the power goes out, and the siren goes off. Types of sirens are divided into the following forms according to structure, function, and application: electronic piezo siren, electronic horn siren (speaker), explosion-proof siren, monophonic siren, polyphonic siren, melody siren, speaker siren, and motor siren. Among the alarm devices mentioned, the most suitable device for the automotive can be seen in Figure 4.

Fig 4. An example of a siren

B. Announcement of fire alarm in digital form on the automotive kilometer screen

In this article, the new idea appears as an alarm and digital signs on the automotive odometer screen. These devices sound the alarm visually in the automotive on the screen or odometer. The types of visual alerts used inside the vehicle include the following items and numbers:

a) Location of the relevant warning light on the odometer

Fire alarm lights are installed and designed along with other warning lights such as control lights (fuel system), seat belt warning lights, and door opening warning lights. In this system, the fire alarm light is placed behind the amp, as shown in Figure 5.

Fig 5. Insertion of the warning light

b) Connecting the fire alarm port to the screen or automotive mileage

The fire alarm port is connected to the automotive screen or odometer to indicate a fire hazard inside the automotive cabin. You can see an example of

Experimental work and implementation of this announcement on the automotive kilometer screen in Figure 6.

Fig 6. Ignition alert display

c) Fuel pump emergency switch

Another innovative proposal of this article is the fuel pump emergency switch, which has the task of shutting off the fuel pump and can be used as a relay or driver. The shutdown command is sent via the microcontroller, and the fuel pump is switched off; As a result, engine fuel transmission is interrupted, thus preventing the fuel tank from exploding into the fuel delivery path. After the condition returns to the first state, the current is reconnected. The location of the fuel pump emergency relay or driver is installed

In the circuit in the pump flow path before the fuel pump.

C. Door opener relay

Another new design of this article is the door lock relay. This relay takes its command from the microcontroller and is connected to the central locking circuit of the automotive doors. As soon as it receives voltage from the microcontroller, it enters the central locking circuit and opens the locks. Figure 7 shows a schematic of the fire extinguishing relay circuit and the central locking.

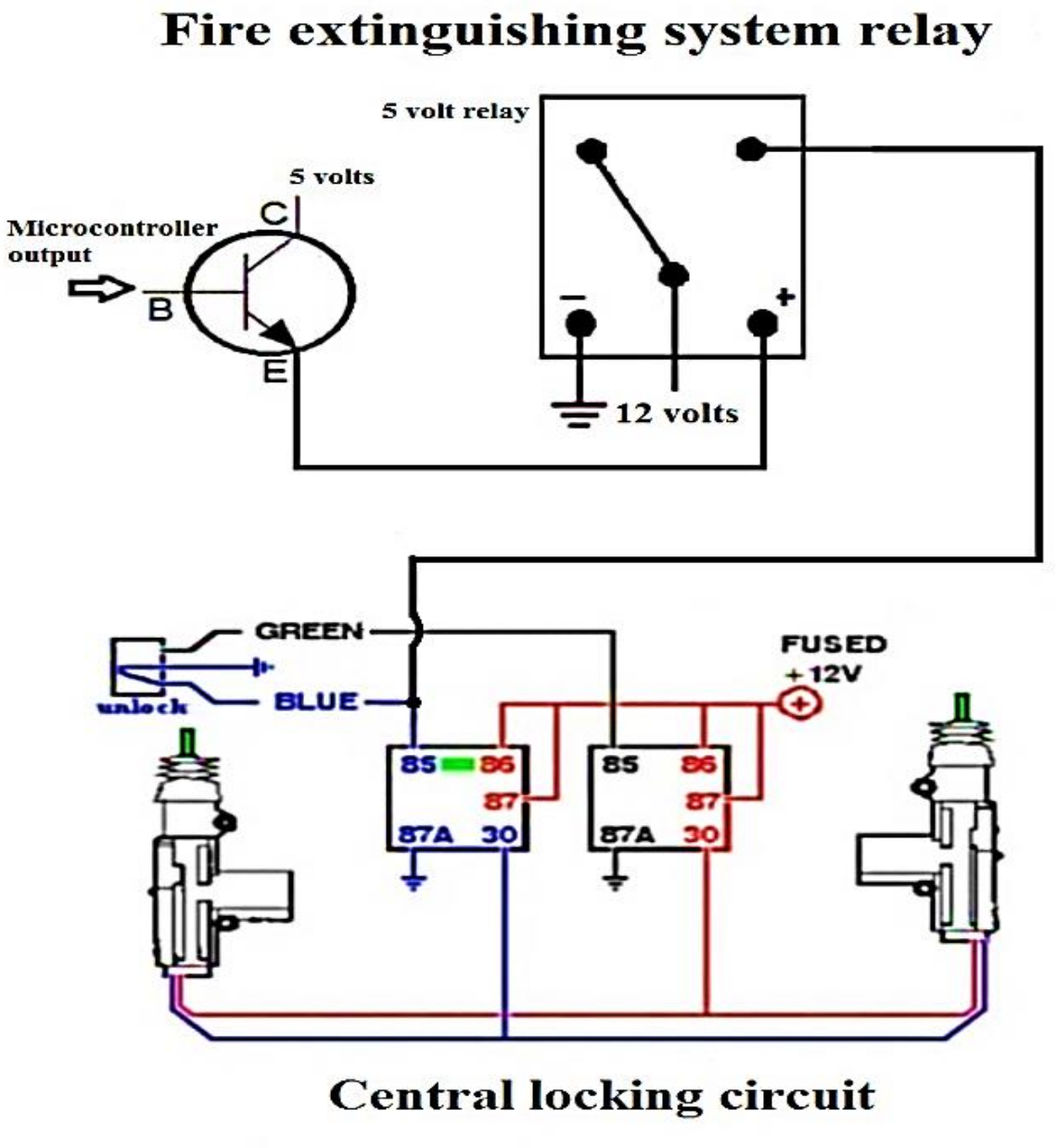

Fig 7. Fire extinguishing relay circuit and central locking

D. Fire extinguishing relay (water)

In this article, the electrical circuit of the automotive fire extinguishing system is drawn according to the new design and installed on the electronic board. A relay is used to cut off and connect the current, which supplies power to the water extinguisher and is normally cut off, but in the event of a fire hazard, there is a fire in

The vehicle after receiving an order from the microcontroller. Connects the flow of the pump and creates the flow pump needed to deliver water to the spray solution and extinguish the fire. When the fire goes out, the pump shuts down and returns to normal. The shape of the electrical circuit of the fire extinguishing system is shown in Figure 8.

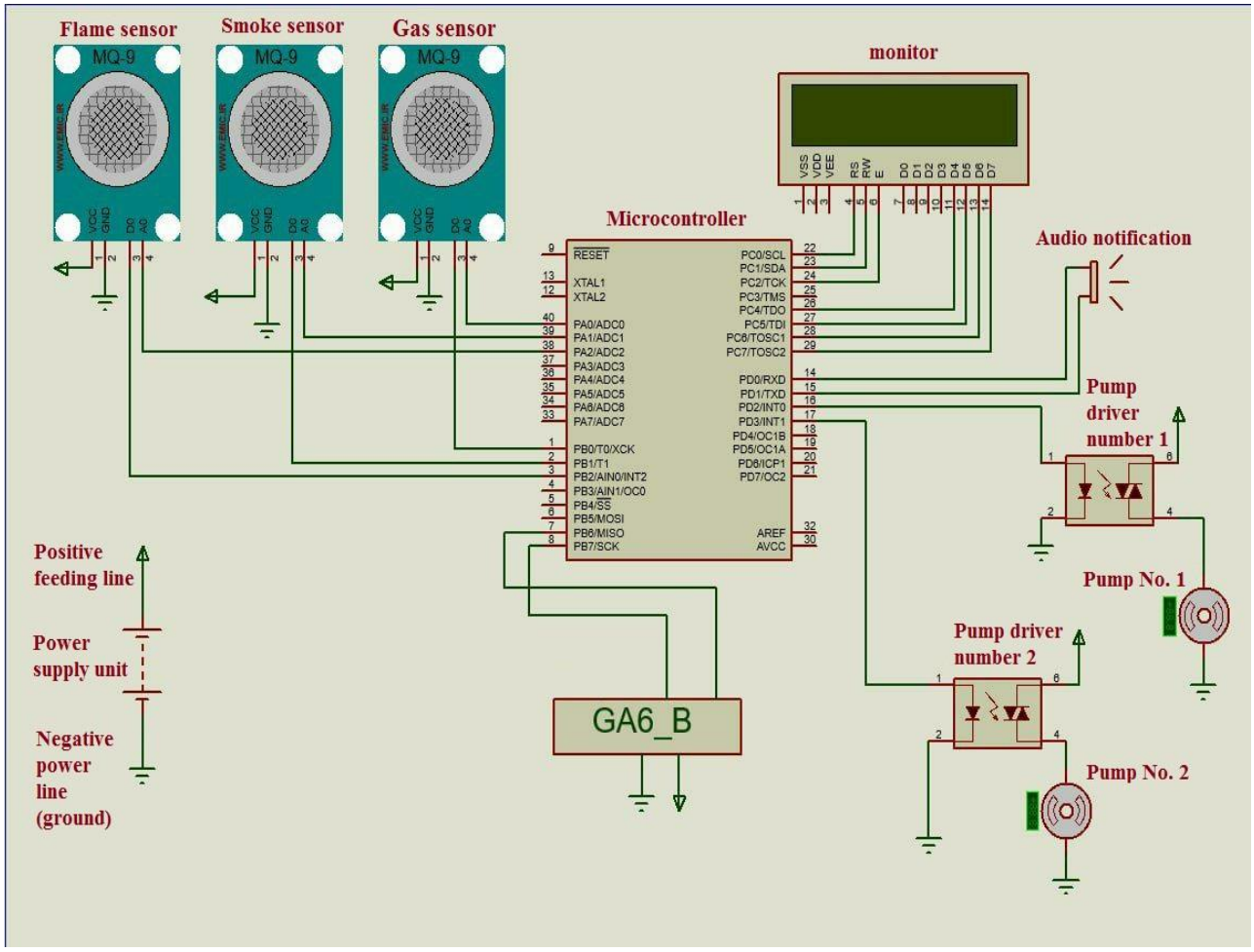

Fig 8. Schematic of the electrical circuit of an automotive fire extinguishing system

E. SIM card module

This piece can communicate via voice call and send SMS to mobile or landline. By receiving a signal from the microcontroller of the fire extinguishing system and then making contact with the driver. In this Section, a telephone number can be defined for this purpose. Examples of SIM card modules include the sim800 series (sim800l, sim800DS, sim800h), GA-6B, etc. Figure 9 shows some examples of these devices.

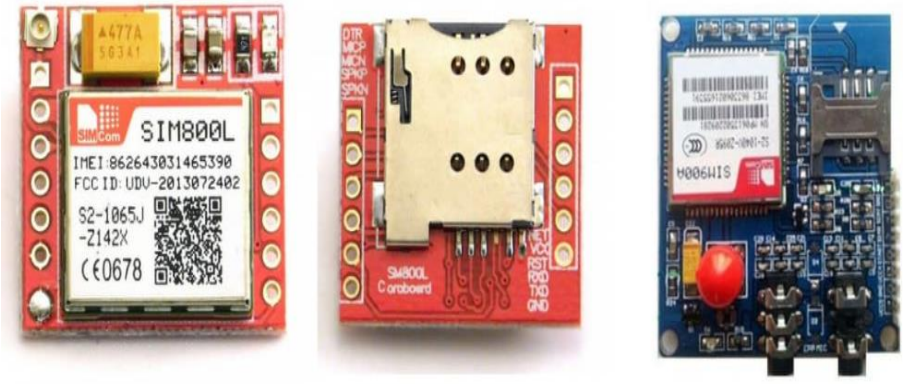

Fig 9. Some examples of SIM card modules

F. Spraying tubes and nozzles:

a) Pipes

The function of the pipes is to establish a connection between the pump tank and the spray nozzles. The automotive fire extinguishing system uses polyethylene pipes and fittings. The advantages of these pipes include resistance (corrosion, decay, and abrasion), good flexibility, long life, lightweight, excellent resistance to vibrations and shocks, low maintenance costs.

b) Spraying nozzles

Spray nozzles are responsible for spraying water liquid on the engine compartment and extinguishing the fire. The spraying nozzles are located on the automotive body and the top of the fenders overlooking the engine compartment. Figure 10 shows the location of the nozzles. In selecting the nozzles, the spray angle and radius are of special importance. The shape of the nozzle is the opposite of the diffuser. The nozzles are divided into two squares and a circle in terms of spray surface. In this system, two square nozzles and a sprayer are used to fill all the desired surfaces (on the motor).

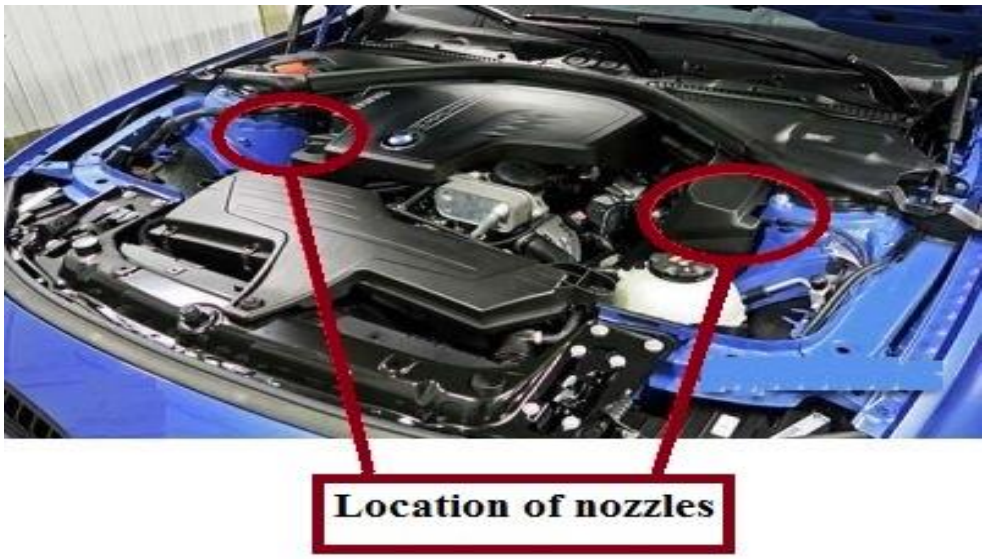

Fig 10. Location of nozzles

V. How the automotive fire extinguishing system works and functions

The purpose of a vehicle fire extinguishing system is primarily to alert the driver and occupants of the vehicle and to issue a fire hazard warning. With this knowledge, you must first leave the vehicle or, if possible, take the necessary steps to turn it off. The second step is to extinguish the fire and prevent the automotive from igniting and exploding as much as possible. The system works in such a way that after the appearance of fire components such as rising ambient temperature, smoke, fuel leakage (liquid, gas), and the formation of a flame, it acts to extinguish the fire. Sensors installed in the engine compartment consist of three sensors, including gas detection sensor, ionization smoke, and fire detection sensor, flame detector sensor. After detecting a fire, these three sensors send signals to the controller (microcontroller), and the controller uses the following data to perform the following tasks:

- Sending a signal to the fuel pump relay to activate the pump and cut off the fuel transmission to the engine fuel supply system
- Sending a signal to the fire extinguisher material (water) pump relay to activate it and generate the necessary water flow to extinguish the fire
- Send a signal to activate the sound alarm (sound alarm)
- Send a signal to activate and turn on the fire alarm light behind the amp or automotive display
- In the event of a fire, the most important factor in preventing casualties is the quick reaction of the occupants to get out of the vehicle.

As soon as the fire occurs, the system, in addition to activating other actuators, sends voltage to the door unlock relays, and if the door locks are closed, the doors are unlocked automatically, and the occupants leave the automotive without wasting time. Figure 7 shows a schematic of the door opener relay circuit and the central locking circuit. Because this action makes it possible to steal it. When activated, the system pumps water from a tank containing water to the spray nozzles. These nozzles are placed in the form of two numbers on top of the engine compartment and on top of the fender and perform the

spraying action with a certain angle and radius downwards. Finally, after the fire symptoms are over, the system returns to its original and normal state. Figure 11 shows an overview of the fire extinguishing system on the vehicle. Finally, we would like to mention the important points that designers and builders, drivers and repairmen should know in order for this system to function properly, that the proper design of the location of the parts according to the intended vehicle is of great importance. For example, the location of sensors and nozzles of fire extinguishers, periodic inspection of different systems is necessary to ensure the operation of the system.

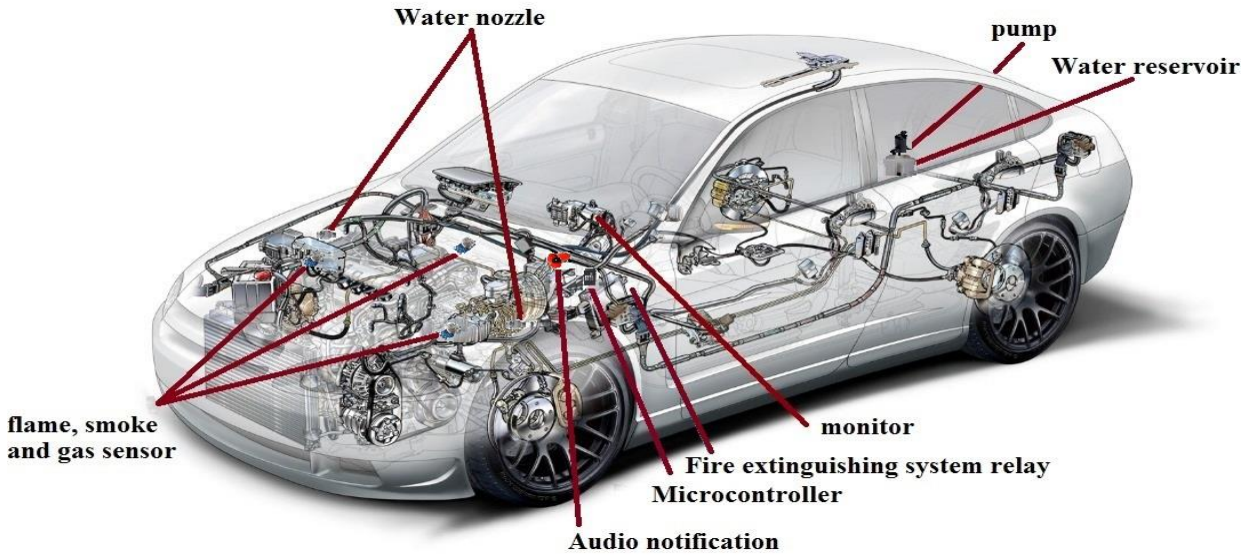

Fig 11. The general shape of the fire extinguishing system on the vehicle

IV. Conclusion

In general, having an automatic fire extinguishing system in the automotive can reduce or prevent financial damage and protect the automotive and its occupants. The condition for achieving this is the proper design of this system and the use of high-sensitivity application components. This system can be used in a variety of vehicles such as light vehicles, trucks, buses, etc. In this article, very new ideas for automotive fire extinguishing systems were proposed, and many experiments were performed on the contents. The first new proposal was the image warning, which was introduced in Figures 5 and 6. The new proposal was a door lock relay, which was Suggested in Figure 7 for further understanding. The newer method was fire extinguishing relay or drive, which according to the description of Figure 8, its electrical circuit is drawn, and with this system, automotive extinguishing can be done. The SIM card module was one of the new suggestions in this article, which according to Figure 9, announced this warning on the driver's mobile phone by calling or sending a text message. The proposal of spray pipes and nozzles was introduced in Figure 10, the location of which was suggested. The new design in this article was suggested in Figure 11, which with its application and proper design, can extinguish fires on vehicles.

VII. Reference

[1] Lees, F., Lees' Loss prevention in the process industries: Hazard identification, assessment, and control. Butterworth-Heinemann, (2012).

[2] Sowah, R., Ampadu, K. O., Ofoli, A., Koumadi, K., Mills, G. A., & Nortey, J., Design and implementation of a fire detection and control system for automobiles using fuzzy logic. In IEEE industry applications society annual meeting,IEEE, (2016) 1-8.

[3] Liu, Q. X., Design of the multifunctional sensor system for the intelligent car. Sensors & Transducers, 161(12) (2013) 518.

[4] Chen, S. J., Hovde, D. C., Peterson, K. A., & Marshall, A. W. Fire detection using smoke and gas sensors. Fire Safety Journal, 42(8) (2007) 507-515.

[5] Esmaeil Mirmahdi, Omid Ghorbani Shirazi., Installation of Suitable Sensors for Object Detection and Height Control on Combine Harvester, *SSRG International Journal of Mechanical Engineering* 8(5) (2021) 12-19.

[6] Ibrahim, D., Microcontroller-based applied digital control. John Wiley & Sons, (2006).

[7] Shrigondekar, H., Chowdhury, A., & Prabhu, S. V., Characterization of a simplex water mist nozzle and its performance in extinguishing liquid pool fire. Experimental Thermal and Fluid Science, 93 (2018) 441-455.

[8] Mathavan, J. J., Faslan, A. W., Basith, N. U. A., & Wanigasinghe, W. V. S. D., Hardware Implementation of Fire Detection, Control, and Automatic Door Unlocking System for Automobiles. In 4th International Conference on Trends in Electronics and Informatics (ICOEI)(48184) (2020) 125-129. IEEE.