ISTANBUL AYDIN UNIVERSITY

COM473 INTERNET OF THINGS & INDUSTRY 4.0

"MOBILE FIRE ALARM AND AIR EVACUATION-CONDITIONING DEVICE WITH WEB PANEL (SEIS)"

Final Report

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Abstract

The implementation of an IoT-based fire-focused smart home system represents a pivotal advancement in addressing fire safety across diverse housing structures. This project aims to fill the safety gap, particularly in older homes, where the absence of modern fire alarm systems has led to tragic consequences. Our solution provides an affordable, easy-to-integrate, and compact system that ensures widespread access to advanced fire detection and prevention measures. By leveraging sensors, Wi-Fi connectivity, and a user-friendly web control panel, our system offers real-time monitoring and automated fan control. This innovation not only simplifies fire safety but also empowers users with manual control options. The project's core mission is to democratize advanced fire safety measures, contributing to safer living environments for all households, regardless of their age or construction.

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1. INTRODUCTION

In the realm of home safety, the specter of fire-related incidents has persistently haunted households, with a particular gravity in older homes lacking modern fire alarm systems. The repercussions of delayed intervention have been tragically evident. Our project stems from a deeply rooted concern for the lives lost and injuries sustained due to this pressing issue. Recognizing the stark gaps in existing fire safety solutions, we embarked on a transformative journey to develop an innovative IoT-based fire alarm system that transcends the limitations of current options.

The landscape of fire safety solutions has witnessed the emergence of various systems, from traditional smoke detectors to sophisticated smart home setups. However, the accessibility of IoT-based smart home systems has predominantly been confined to luxury residences, and traditional detectors are often exclusive to newly constructed homes. The primary reason behind this gap lies in the integration process, which is inherently easier during the construction phase.

Our mission is to dismantle these barriers and democratize fire safety. We envision a future where an IoT-based fire alarm system is not a luxury but an essential component of every home and office, effortlessly deployable without the need for structural modifications. This initiative is not merely about introducing a product; it is a crusade to make cutting-edge fire detection and prevention an integral part of every living space, regardless of its age or construction. Through this project, we strive to pioneer a paradigm shift in home safety, ushering in a new era of comprehensive protection, peace of mind, and swift responses to fire emergencies for individuals and families worldwide.

2. PROBLEM STATEMENT

Every year, residential fires claim lives and cause injuries, perpetuating a critical issue that demands urgent attention. The problem is exacerbated, particularly in older homes, where the absence of modern fire alarm systems leaves inhabitants vulnerable to devastating consequences. Despite the existence of fire detectors and smart home solutions, the deployment of these technologies is predominantly confined to luxury residences or newly constructed buildings.

The crux of the problem lies in the challenges associated with retrofitting conventional fire safety systems into existing structures. Modern smart home systems often necessitate expensive electrical panels and extensive renovations, rendering them impractical for widespread adoption. As a result, a substantial portion of the existing building stock remains devoid of these life-saving technologies.

This gaping void in fire safety infrastructure is a significant concern, leading to delayed interventions and, tragically, loss of life. The lack of accessible, affordable, and easy-to-integrate fire safety solutions further compounds this issue. Our project is a direct response to this pressing problem, aiming to bridge the safety gap by introducing an innovative IoT-based fire alarm system. By providing a cost-effective, easily deployable, and retrofit-friendly solution, we strive to revolutionize fire safety, making advanced detection and prevention measures accessible to households of all types and ages.

3. LITERATURE REVIEW

We divided literature review two part. First, we researched existing systems then we conducted a feasibility study to see the social orientation.

Traditional Fire Detection Systems:

Traditional fire detection systems, primarily consisting of smoke detectors and alarms, have been the foundation of residential fire safety for decades. These systems, while effective, often lack the sophistication required to address the complexities of modern living environments.

Smart Home Systems:

The advent of smart home technology has introduced a new dimension to fire safety. Integrated systems capable of monitoring various environmental factors and alerting homeowners remotely have become increasingly prevalent. However, these solutions are often complex, expensive, and predominantly accessible to a niche market.

IoT-Based Fire Safety Systems:

The emergence of Internet of Things (IoT) technology has spurred innovation in fire safety. Integrating IoT with fire detection systems allows for real-time monitoring, data analysis, and remote control. However, literature suggests that many IoT-based solutions remain confined to high-end residences, leaving a gap in accessibility.

Fire Incidence and Casualties:

According to the U.S. National Fire Protection Association (NFPA) and other global fire safety agencies, residential fires remain a significant cause of property damage, injuries, and fatalities.

Statistics often highlight the disproportionate impact on older structures due to outdated fire safety infrastructure.

Smart Home Adoption:

The global smart home market has been steadily growing, with an increasing number of households adopting smart technologies. However, the penetration of comprehensive smart fire safety systems may still be limited, and such systems are often considered a luxury in residential construction.

Challenges in Older Homes:

Research indicates that retrofitting modern technologies into older homes presents challenges due to differences in construction standards and the absence of pre-installed infrastructure.

Older homes may lack essential safety features, contributing to a higher risk of fire-related incidents.

Costs of Smart Home Renovations:

Studies suggest that the cost of implementing a full-fledged smart home system, including electrical panel upgrades and renovations, can be a significant barrier to widespread adoption. Homeowners, especially in older properties, may be deterred by the financial implications of such upgrades.

IoT and Fire Safety Trends:

The Internet of Things (IoT) is increasingly being integrated into various industries, including fire safety. However, the deployment of IoT-based fire safety systems may be skewed toward high-end homes or new constructions, limiting their impact on existing structures.

Fire Safety Awareness:

Public awareness of fire safety measures is a crucial factor in preventing incidents. Educational campaigns and technological innovations play a role in enhancing awareness and promoting proactive safety measures.

By addressing these trends and challenges, our project aims to contribute meaningful solutions to the existing landscape, making IoT-based fire safety accessible, affordable, and applicable to a broader range of homes, including older structures that may currently lack modern fire prevention systems. For the latest and most accurate statistics, it's recommended to refer to authoritative sources and recent publications in the field of fire safety and smart home technologies.

4. SYSTEM

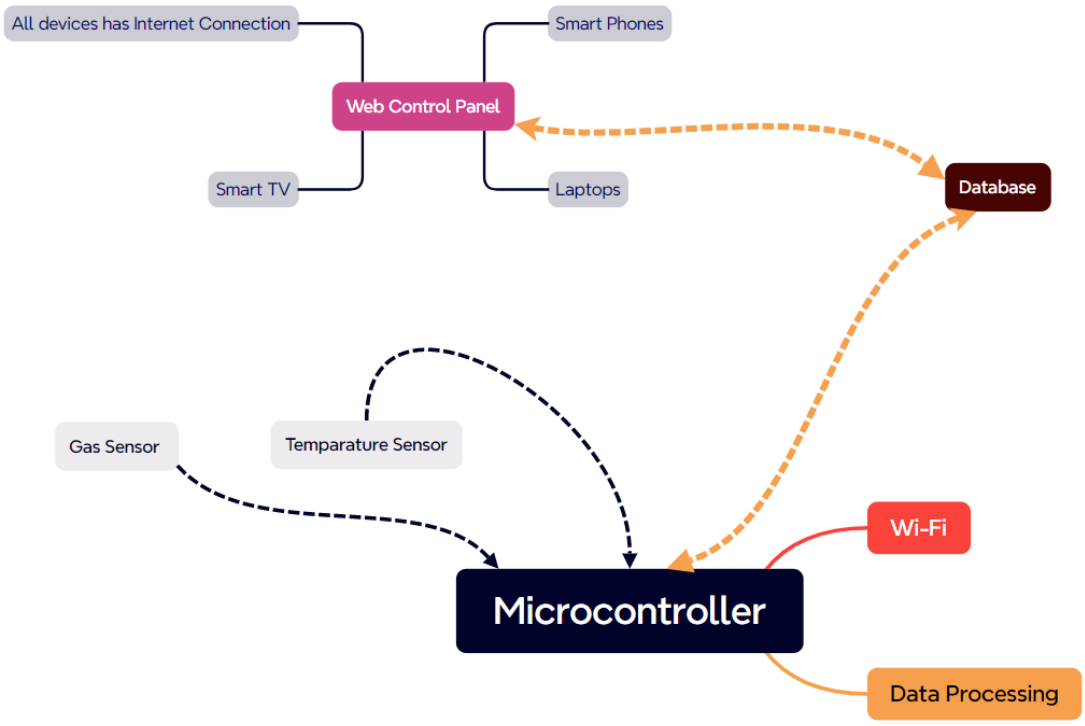


Figure 1: System Basic Image

Basically, our microcontroller controls and process everything automatically. And we are saving our data with a database. For user interface, you can control your system with web control panel over the database.

5. COMPONENTS

ESP32-WROOM-32D

If you are interested in connecting your project to the Web and being a part of the IOT (Internet of Things) project, this development board is for you! Like other microcontrollers and microprocessors, the ESP32 is built in power regulation circuits, on-board antennas, noise filters, and fits snugly on any breadboard for rapid prototyping.

Figure 2: ESP32

Manufacturer	Espressif
Product Category	Wifi Module
Sherry	ESP32-WROOM-32D
Operating voltage	2.2 - 3.6VDC
32 GPIO	ADC (16), SPI (2), I2C (1), UART (1), PWM (32), SDIO (50 Mhz)
SRAM	520 KB
Flash	16 MB
WiFi Transceiver	802.11BGN HT40 WiFi Transceiver (-98 dBm minimum sensitivity)
Maximum Data Rate	150 Mbps
Operating temperature	-40 ° C to 125 ° C
Size	29.22mm x 98.58mm x 17.22mm

FAN

Figure 3: Fan

Manufacturer	HENGTAI
Product Category	Fan
Dimensions	40x40x10mm
Rated Voltage	12V
AC / DC	DC
Rated Current	0.06A
Power	0.72W
Speed	7000RPM
Air flow	7.5CFM
Sound Level	32dB-A
Number of Pin	2nd
Station	Cable
Bearing Type	Sleeve
Wheel	Plastic
Number of Wings	9
Operating temperature	-10 ° C ~ + 70 ° C
RoHS	RoHS

MQ-2 Gas Sensor

MQ-2 gas sensor high on gas, propane, hydrogen sensitivity of detection of natural gas and other flammable vapors are also very good. This sensor can detect a variety of flammable gas, is a low-cost sensors for a variety of applications.

Figure 4: MQ2 Sensor

The MQ2 gas sensor is commonly used to detect various gases like LPG, propane, methane, alcohol, benzene, and smoke. Its operational principle relies on measuring the quantity of gas in the air. When these gases interact with the sensor, they cause a change in its internal resistance, which is then detected as an output signal.

It finds applications in security systems, fire detectors, industrial environments, home automation systems, among others. However, due to factors such as sensitivity, susceptibility to environmental conditions, and accuracy, precise calibration might be required to accurately determine which gas is being detected and at what concentration.

DHT22 Digital Temperature and Humidity Sensor

It is a basic, low-cost, digital temperature and humidity sensor. A capacitive humidity sensor and a thermistor are used to measure the surrounding air. It sends a digital signal to the data pin. This completes the reading process.

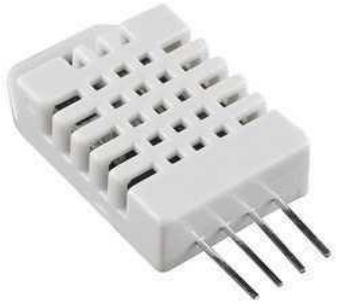


Figure 5: DHT22 Sensor

The DHT22 is a digital sensor designed for measuring temperature and humidity. It stands out for its precision and accuracy. This sensor is specifically engineered on a single integrated circuit to detect both temperature and humidity.

It provides digital output and can be seamlessly integrated into a microcontroller or any other digital device. Its temperature measurement range typically spans from -40 to 80 degrees Celsius, while its humidity measurement range usually varies between 0% to 100%.

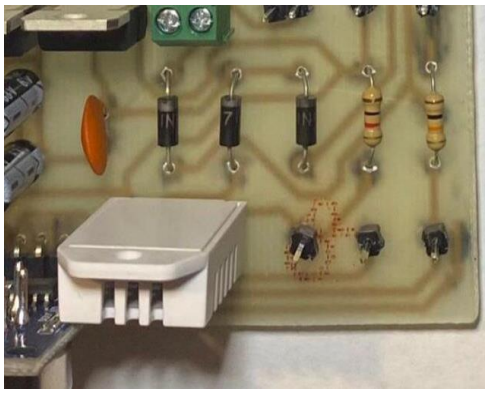


Figure 6: DHT22 at our PCB Board

The sensor's operational principle involves using a thermal component for temperature measurement and a capacitive humidity sensor for humidity measurement. This unique feature allows it to accurately measure both temperature and humidity simultaneously.

The sensor finds applications across a broad spectrum, ranging from home automation systems to greenhouse control, weather monitoring stations, and industrial automation. Its precision

and digital output simplify data acquisition and processing, ensuring reliable data for distribution and control systems.

7805CV Voltage Regulator

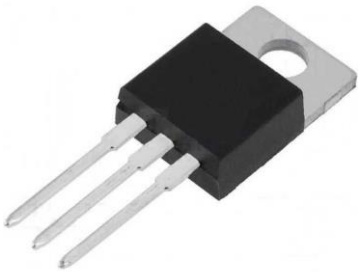


Figure 7: 7805CV Voltage Regulator

The L7805CV is a TO-220 three-pin linear regulator based on the commonly found 7805 that has a maximum input voltage of 35 V, a maximum output current of 1.5 A, and a fixed output voltage of 5 V.

Manufacturer	STM
Product Category	Linear
Sherry	L78
Resolution	N / A
Supply Voltage (Max.)	35 V
Supply Voltage (Min.)	7 V
Sheath Type	TO-220
Mounting Type	BOTTOM
Minimum Process Temperature	° 0 C
Maximum Process Temperature	° + 125 C

IRF510 N Channel Power Mosfet

Figure 8: IRF510N MOSFET

IRF510, N Channel Mosfet TypesIt is from the inside and is covered with TO-220.N Channel Power MosfetIt is of type. The IRF510 has a 100V Gate-Source voltage and 5.56A continuous output current.

Name of the product	IRF510
Product Category	Mosfet
Product Sub-Category	IRF Series
Package Type	TO-220
Transistor Type	N Channel
Continuous Output Current	5.56A
Drain-Source Voltage	100V

Other Components

- 12V Adapter
- Resistors, capacitors, diodes and copper board

6. CIRCUIT SCHEMATIC AND HOW IT WORKS?

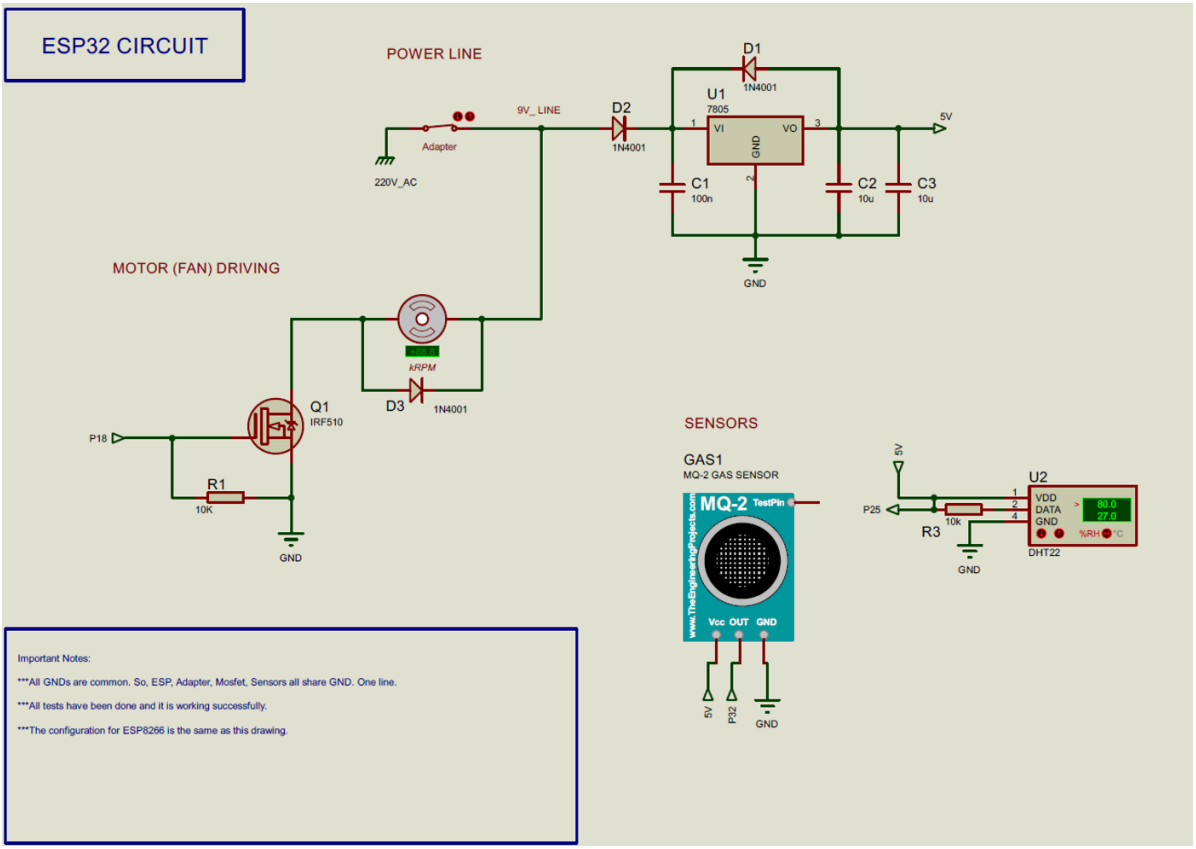


Figure 9: PROTEUS Simulation Schematic

The circuit operates by plugging an adapter, reducing the circuit from 220V to 9V, into the socket. Once power is supplied to the circuit, 7805CV efficiently drop the voltage from 9V to 5V. Following the circuit's working principle, data from the MQ2 gas sensor and DHT22 temperature sensor is transmitted to the ESP32 card. And ESP32 process it. Then the ESP32 card transferring the data to the Firebase Realtime Database. Through our website, users can promptly view real-time sensor data. If desired, users can manually adjust the speed data on the website to control the fan connected to the load circuit. Given the system's versatility across different applications, the website can display multiple panels. Information on the website is presented in user-friendly measurement units commonly used in daily life for easy comprehension.

To operate our fan, we are using IRF510 MOSFET. And we are driving the MOSFET with PWM signals producing from ESP32 microcontroller. And we are using C++ software language to program ESP32.

We create an extremely safe system by converting the 220V AC motor we receive from the network to 5V DC with good engineering work.

At the web side, we are using HTML, CSS, JavaScript software languages. And we have domain named “iotproject-dc0cb.web.app”.

To control your IOT device, first of all you need to login your account. After login, you will see your devices. And then, you can easily control and monitorize your system.

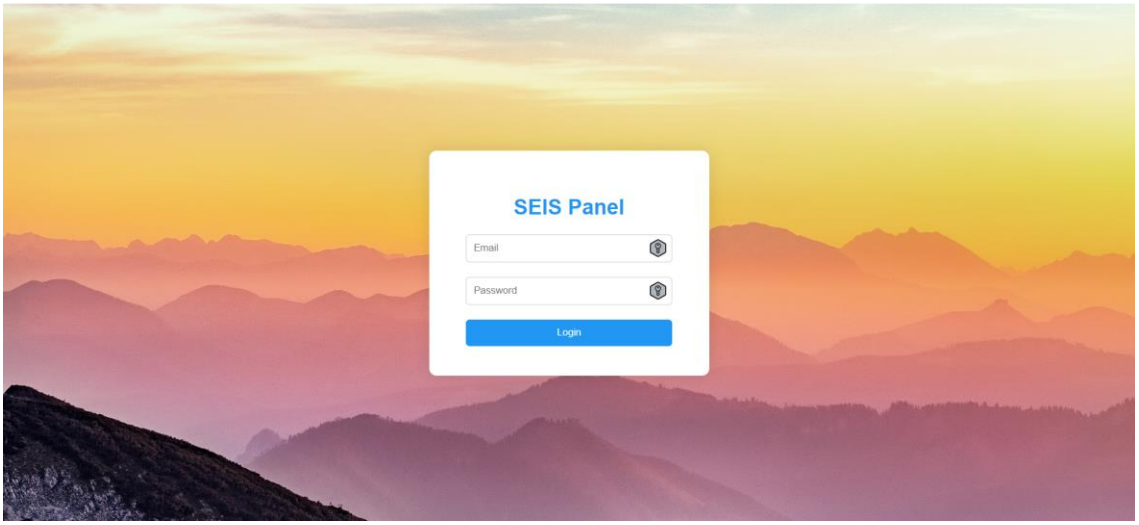


Figure 10: Web Panel Login Screen

In the control pane you can see the temperature as a Celsius and gas as a ppm values. And according to this values microcontroller arranges fan speed automatically. But if you want, you can control the fan manually from here by clicking the M/A button (A text field will appear, then you should type percentage you want).

Above the 1050 ppm or 30 degrees, device accepts it is as a dangerous situation and fan works %100. Below 1050 ppm or 24 degrees accepts as a normal situation and fan does not work. And fan speed mapped among the 24 and 30 degrees. It automatically controls the speed according to the temperature.

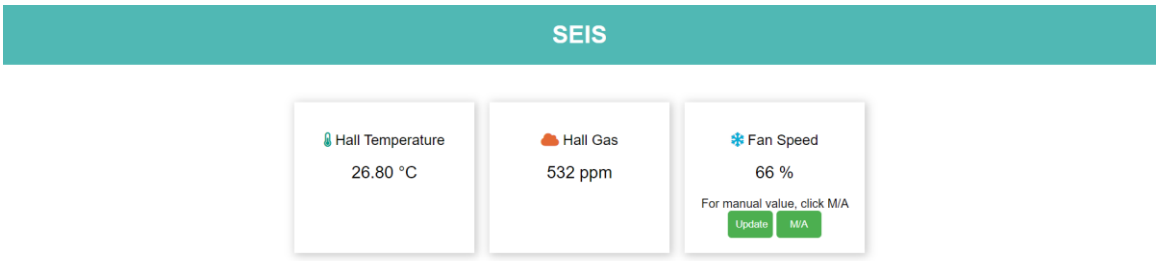


Figure 11: Web Control Panel

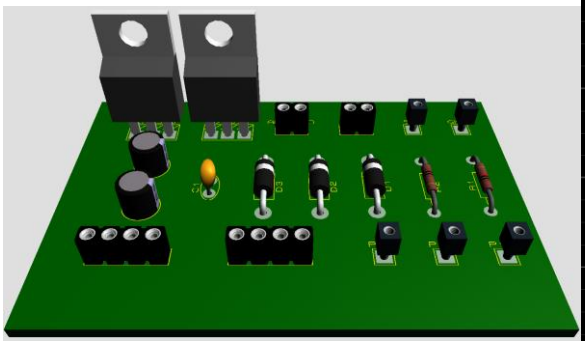
For summary, the microcontroller connects to the Wi-Fi at home, detects temperature and smoke with the sensors on it, processes the data and sends it to the Firebase Realtime Database. Then you can see and control this data on the website we have made.

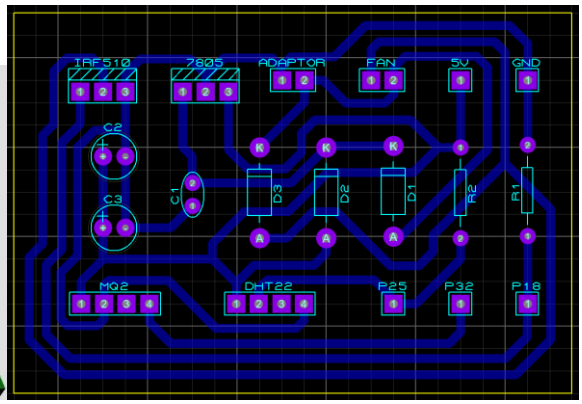
7. PRODUCTION STAGES

DESIGNING A PCB BOARD

Designing a PCB (Printed Circuit Board) board with Proteus involves several steps. Proteus is a powerful software suite that combines an integrated development environment (IDE) and a PCB layout program. It includes tools like the space-based auto-router, fully-featured schematic capture, highly configurable design rules, an interactive SPICE circuit simulator, and an integrated 3D viewer

First, let's click on this button () to design the PCB of the circuit we drew in the Proteus program. After clicking this button, a blank worksheet will appear. In this section, we see the tools section on the left and first we need to create a copper plate to place the circuit elements. To do this, we first click on the 2D Graphics Box Mode button()on the left, then select the copper plate from the textbox section at the bottom left and draw a copper plate in dimensions suitable for our circuit. From the component mode button () on the left, we place the components we use in the circuit into the copper plate we drew. When placing circuit elements in Proteus ARES (We call the PCB design part ARES), focus on logical component arrangement, short signal traces, solid power/ground planes, signal integrity, proper orientation, clearance, thermal considerations, clear labels, careful routing, adherence to design rules, 3D visualization, and be prepared for design iterations. Since our circuit is not a very complex circuit, we draw the connections as a single layer. While drawing the connections, we press this button ()from the menu on the left and select the thickness of the paths.





(Figure 12) (Figure 13)

(Figure 12) Before starting to draw the connections, we have to check 3D visualization because some component can be bigger what we see.

(Figure 13) After drawing the connections.

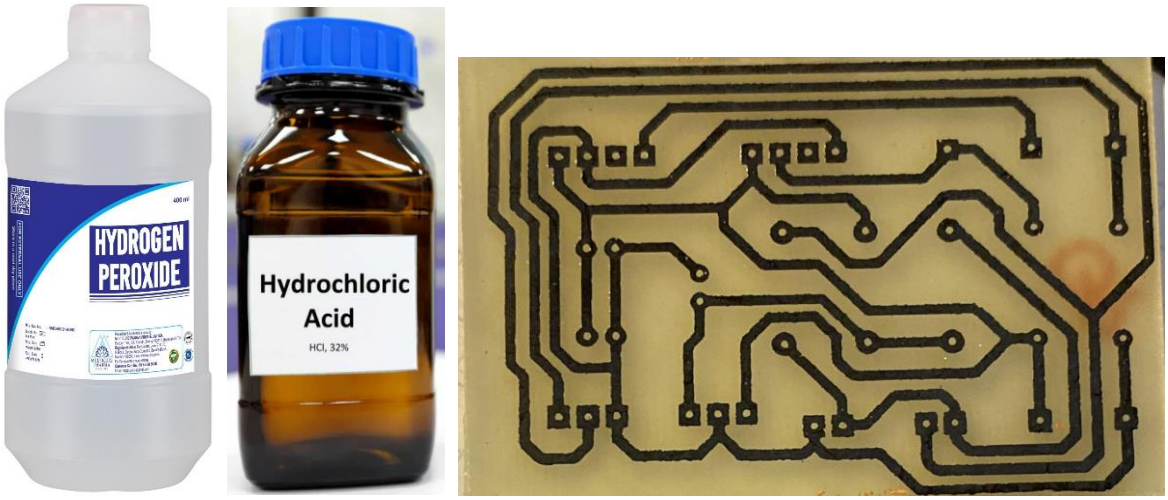
APPLYING THE DESIGNED PCB BOARD TO REALITY

After the drawing is completed in professional work, it is given to companies that produce PCB cards and production is carried out. However, we will discuss handmade PCB board here.

After completing the drawing, we need to print the connection diagram on glossy paper. To print this diagram, we click on the Print Layout option (Print Layout)from the Output menu at the top. In the opened tab, we simply select the bottom copper option, click the ok button and save. We do not change the size of the circuit after saving. And we are ready to print it. We have some rules for printing , first one as I mentioned before glossy paper and the second one is printer feature. The printer should be toner printer or laser printer not ink printer.

After printing our circuit, we can start preparing the copper plate. We clean the surface of our copper plate with the help of sponge and powder detergent and make it easier for the paint to adhere to the surface. After surface cleaning, we dry the copper plate. We place the printed circuit on the dried copper plate and by applying heat, we ensure that the circuit transfers to the copper plate. We apply heat using an iron. After applying heat for about 3-4 minutes, we throw the copper plate into the bowl filled with water.

When the paper enters the water, it softens and we clean the paper with our hands. But the painted area passes onto the surface of the copper plate. Now we can throw our copper plate into the acid. When we put it in acid, it will melt except for the painted parts and we will establish our connections. Our acid solution consists of hydrogen peroxide and hydrochloric acid and our mixing ratio is 3:1. After this process, we can drill holes to place the components.



(a) (b) (c)

(a) Hydrogen Peroxide

(b) Hydrochloric Acid

(c) After Throwing Into Acid Solution

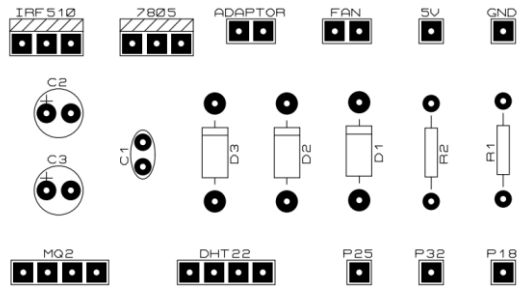
Figure 14

PLACING CIRCUIT ELEMENTS ON THE PCB BOARD

Soldering is a process used to connect electronic components to a circuit board efficiently. The preparation involves organizing the workspace and ensuring safety measures are in place. Necessary equipment such as a soldering iron, solder wire, and flux should be prepared. The soldering iron is heated to a specific temperature, and the components and circuit board are cleaned. Components are then correctly positioned, and flux is applied to aid solder flow. Using the heated soldering iron, solder wire is applied to the component leads and soldering points on the board. After completion, residue is cleaned, and a visual inspection is performed to check for any cracks or deficiencies in the solder joints.

Throughout the process, safety precautions should be observed, particularly regarding solder fumes.

We placed components as shown in FIGURE 15 and soldered the circuit elements as shown in FIGURE 16.



(FIGURE 15)

AFTER SOLDERED (FIGURE 16)

Finally, our board look like that:

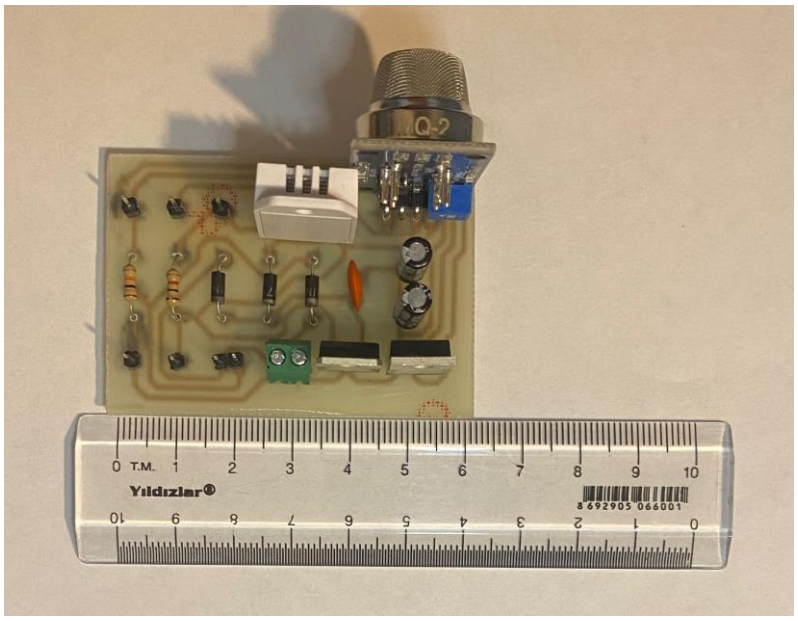


Figure 17: PCB Board

When we add the other parts, it looks like this as a whole:

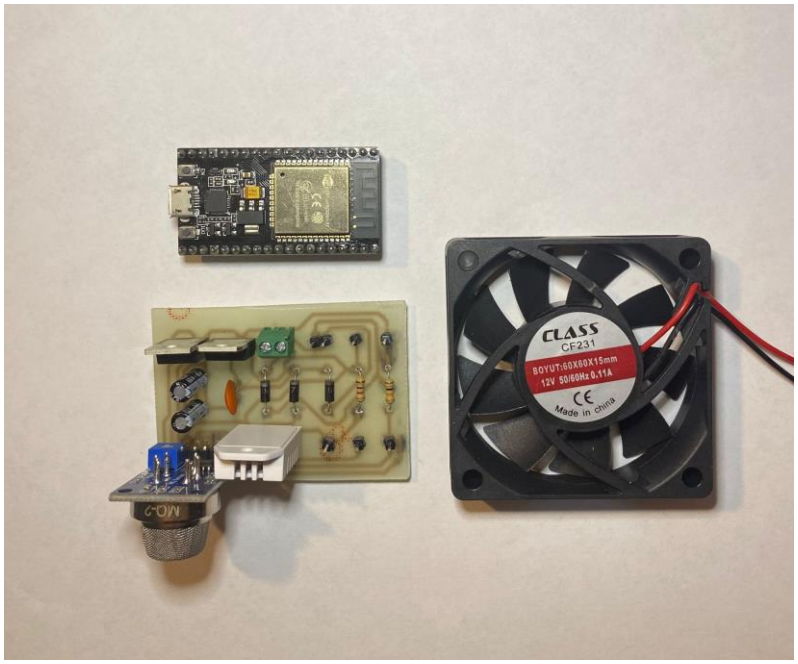


Figure 18: Whole System

For summary, our system is IOT based, low cost and easy to integrate and very small. Fan for gas evacuation or air conditioning operations.

You can use this system anywhere in your home. But we suggest you should use this system on important points of your home. For example, you can install it on these air outlets in your home.

Figure 19: Air Outlet

8. CONCLUSION

In conclusion, the implementation of our IoT-based fire-focused smart home system marks a significant leap forward in addressing the critical issue of fire safety in both old and new houses. The motivation behind this project stems from the unfortunate incidents of fire-related fatalities, particularly in older homes lacking modern fire alarm systems. Our forward-thinking approach aims to bridge existing safety gaps, offering an innovative solution that can be seamlessly integrated into homes of any age without the need for extensive construction.

Traditionally, fire alarm systems and smart home solutions have been confined to specific types of residences, with luxury homes often adopting IoT-based technologies, leaving the majority of homes without adequate protection. Our system challenges this norm by providing an affordable, easy-to-integrate, and compact solution that ensures every household can benefit from advanced fire detection and prevention measures.

As depicted in the comparison of traditional fire alarm systems and complex smart home setups, our IoT-based solution stands out for its simplicity and cost-effectiveness. The system's core, equipped with sensors for temperature and smoke detection, connects seamlessly to the Wi-Fi at home, relaying crucial data to the Firebase Realtime Database. This data is then accessible through a user-friendly web control panel, allowing homeowners to monitor and, if necessary, control the fan manually.

The intelligence of our system lies in its ability to automatically adjust fan speed based on real-time data, ensuring a swift response to potential fire emergencies. The predefined thresholds for gas concentration and temperature provide an additional layer of safety, activating the fan at full capacity in dangerous situations and maintaining a lower speed in normal conditions. This automated approach not only enhances the effectiveness of fire prevention but also offers users the flexibility to take manual control if desired.

In essence, our IoT-based fire-focused smart home system is not just a technological innovation; it is a solution designed with a humanitarian mission – to save lives and prevent injuries. By democratizing advanced fire safety measures, we aspire to contribute to the creation of safer and more secure living environments for individuals and families, irrespective of the age or construction of their homes. This project represents a transformative step towards a future where fire safety is accessible to all, ultimately making a positive impact on communities worldwide.

9. REFERENCES

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