ISSN (Print) : 2337-9030 ISSN (Online) : 2685-2608
PILLAR OF PHYSICS
JURNAL BERKALA ILMIAH FISIKA
Vol. 18 (1), 2024, page. 10-20
DOI : 10.24036/16845171074

PROTOTYPE OF EARLY DETECTION AND HOME FIRE EXTINGUISHING SYSTEM BASED ON IOT AND GPS

Peto Syarif[1], Mairizwan[1*], Asrizal[1], Yohandri[1]

[1] Department of Physics, Universitas Negeri Padang, Jl. Prof. Dr. Hamka Air Tawar Padang 25131, Indonesia

Corresponding author. Email: mairizwan@fmipa.unp.ac.id

ABSTRACT

House fires are a serious risk that results in both huge material damage and fatalities. According to the Padang City Fire Department, there were 198 fire cases in 2023 and 230 in 2022. Despite the decrease, the risk of fire is still a serious threat due to delays in detection and response caused by late information and incorrect address determination from the reporter so that firefighters are late to extinguish it. This research designs a prototype of an automatic fire detection and extinguishing system in homes based on IoT and GPS technology. This research uses engineering research methodology by combining an IR flame sensor for fire detection, an MQ-135 sensor for CO_2 gas monitoring, and a NEO-7M GPS module for location tracking. The system uses Arduino Uno and ESP32 NodeMCU for IoT-based data processing. The test results show a measurement accuracy of 96.27% for voltage and 97.56% for CO_2 concentration. The precision measurement value shows 99.81% for voltage and 98.31% for CO_2 concentration. The system was tested in a fire simulation scenario on a 50x50x50 cm prototype, equipped with water pump and exhaust fan actuators, as well as a user interface through Blynk and WhatsApp applications for real-time monitoring and notification. The early warning system operates effectively with a response time of 5-15 seconds, while the actuators work according to the sensor data set point to activate the automatic fire extinguishing system. It can be concluded that the prototype design has worked well and can efficiently use GPS-based real-time alerting, automatic extinguishment, and multi-parameter detection (fire and smoke) to reduce risk and losses due to fire..

Keywords : Fire; IoT; GPS; Early Detection System; Prototype.

I. INTRODUCTION

Fire is a kind of disaster caused by fire or infrequent combustion, which has the potential to cause large damage and loss of life [1]. Widespread and uncontrolled fires can result in emergency situations that require special handling from the authorities and involve extinguishing efforts by firefighters [2]. Fire hazards can occur unnoticed because there are many opportunities that can trigger a fire, and the delay in detecting the fire causes the fire to spread so that the impact is very detrimental [3]. The causes of fire disasters can be diverse, such as human negligence, accidents, electrical short circuits, sabotage, or natural factors such as hot and dry weather [4]. Fire disaster management involves extinguishing efforts by firefighters, evacuation of residents, rescue of victims, and mitigation efforts to prevent further impacts [5].

The main problem that occurs when there is a house fire is the delay in handling assistance from the firefighters [6]. This is caused by a number of things, including the fact that fire reports are often submitted late because the homeowner was not present at the scene of the fire and the reporter's address or location is inaccurate, which delays or prevents firefighters from reaching the scene [7]. Therefore, in order to avoid and reduce the risk of fire, technology that can assist in solving these issues is required.

The Internet of Things (IoT) is a technology for developing network communications from interrelated objects connected to each other via internet communication and to exchange data, which can then turn it into real-time information [8]. Global Positioning Systefanm (GPS) is a satellite-based navigation and positioning

Submitted: Nov 15, 2024 Accepted: April 29, 2025 Published: April 30, 2025

system. Users usually use GPS trackers or GPS tracking devices to receive satellite navigation signals. This technology allows users to track the location or position of satellites [9]. By utilizing IoT-based fire detection sensors, the system can detect the presence of smoke, heat, or fire in real-time [10]. Therefore, this technology can be used as a home state monitoring system that can inform residents when a fire occurs by sending warning notifications and geographic fire location information to user devices in real-time. So that the fire handling process can be done more quickly and precisely.

In the research entitled “Design of an Internet of Things-Based Fire Extinguishing System," a fire alarm system has been designed using the MQ-2 sensor, DHT-22 sensor, IR flame sensor, and using the ESP32 microcontroller. The results of this research are the development of an IoT-based fire detection tool equipped with water sprinkler and alarm features, as well as integration with the Telegram application for fire notification. [11]. Another research titled “Fire Early Warning and Handling System Based on the Internet of Things.” The system uses 3 sensors, namely the IR flame sensor, MQ-2 sensor, and DHT-11 sensor. Assembled on the NodeMCU ESP8266 microcontroller. The system can send information to the user through the Blynk application on a smartphone [12]. The next research is entitled “Fire Early Warning and Handling System Based on the Internet of Things.” The system uses 3 sensors, namely the IR flame sensor, MQ-2 sensor, and DHT-11 sensor, and is assembled on the NodeMCU ESP8266 microcontroller. The results of this study are that the system can detect fires and gas leaks and has an extinguishing system in the form of a water pump and exhaust fan. The system can send information to the user through the Blynk application on a smartphone. The system designed in this research is limited in that the system has not used a GPS tracker, there is no warning notification feature sent to the user, and it still uses a 1-channel IR flame sensor [13].

Therefore, a study entitled “Prototype System for Early Detection and Home Fire Extinguishing Based on IoT and GPS” was designed. From this research, a system prototype was designed, where the prototype method is an approach that involves iterative steps from requirements gathering to system implementation. The goal is to get an initial overview and identify the necessary components [14]. From this research, a prototype system is designed where this research uses a “GPS” tracking device that can track the location of fires accurately and in real time, which is integrated into Google Maps and IoT-based, which will be sent to the WhatsApp application as an early warning system and the Blynk application as a user interface. This research uses Arduino Uno and NodeMCU ESP32 as microcontrollers to process IoT-based data, equipped with a 5-channel IR flame sensor as a fire detector and sensor. MQ-135 as a CO_2 gas detector. For an automatic extinguishing system using a water pump actuator as a fire extinguisher and an exhaust fan as a temperature controller and removing smoke (CO_2) due to fire results.

II. METHOD

This is a type of engineering research. Engineering research is a design activity that requires new contributions in each activity, both in the form of processes and products or prototypes. In this research, the discussion of design activities involved things that are relatively new [15]. The stages of engineering research start from finding ideas and task clarity, conceptual design, arrangement, geometry and functionality, detailed design, prototyping/modeling, and finally the testing stage. Tool design includes work related to block diagrams, hardware design, and software design [16].

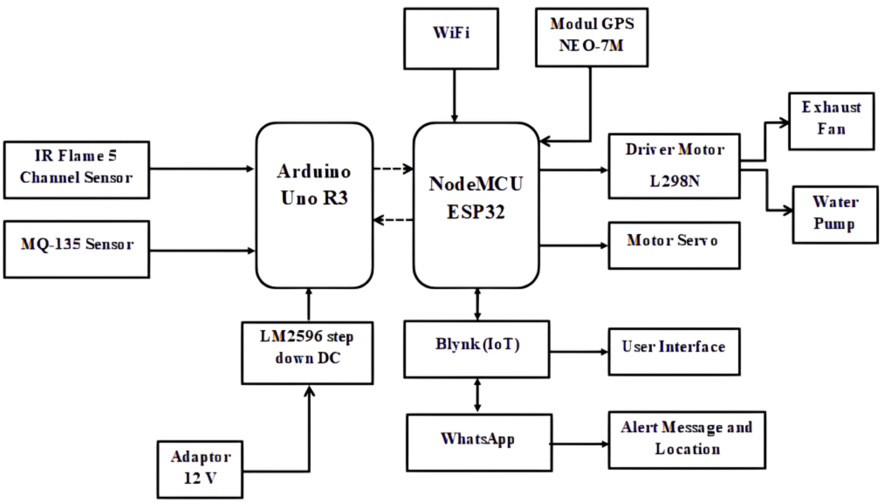


Fig. 1. Block diagram of system prototype

Figure 1 is the block diagram of the system prototype. This system consists of an Arduino Uno R3 and NodeMCU ESP32, a GPS NEO-7M module, an L298N motor driver, an LM2596 DC step-down module, a water pump, a exhaust fan, a servo motor, a switch, a 12 V adapter, a 5-channel IR flame sensor, and an MQ-135 sensor. This system is divided into a power source, microcontroller, actuators, sensors, and several other supporting components. The power source consists of a 12-volt adapter connected to a DC step-down LM2596 module to reduce the voltage, resulting in an output voltage of 5 volts, which will be supplied to the components that require that voltage. The working principle of the system involves separating several electronic components that will be used and will function according to the instructions given by the program later. The block diagram above will determine the relationship between the electronic components in three stages: input, processing, and output.

The hardware design explains the physical parts of the system. Meanwhile, software design serves as instructions for hardware to complete its tasks.The hardware design aims to create the system design and supporting circuits so that the system can be built [17]. Software design is carried out to simplify the operation of the prototype system [18]. Here is the hardware design of a prototype system for early detection and home fire extinguishing based on IoT and GPS, as shown in Figure 2, and the following flowchart system prototype can be seen in Figure 3.

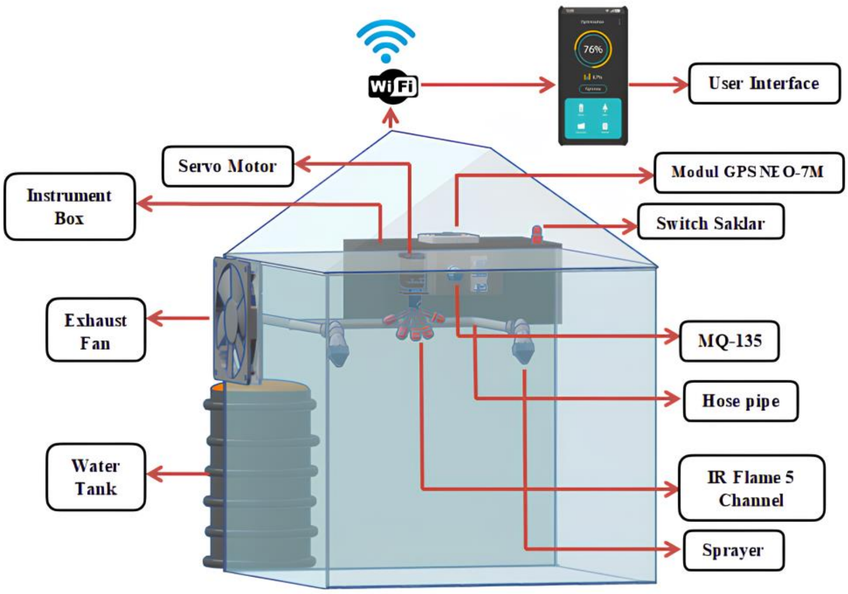


Fig. 2. System prototype design

Figure 2 shows the system prototype design. The design material used is acrylic glass. In this mechanical design, the dimensions of 50 cm x 50 cm x 50 cm are used to simulate a room. This system consists of various sensors and integrated electronic components. The control center is located in the instrument box. Sensors such as IR flame and MQ-135 are installed to detect fire and CO_2 concentration. An IoT-based microcontroller processes the sensor data and sends it to the user's smartphone via WiFi connection. This allows real-time monitoring of home conditions remotely. If signs of fire are detected, the system will activate the actuator in response. In the middle of the prototype, there is a servo motor that is paired with a 5-channel IR flame sensor as a fire detection radar that is capable of detecting a 360-degree area. On the side there is an exhaust fan to control and remove smoke (CO_2) from the fire (air circulation regulator) on the prototype. At the bottom of the prototype there is a water pump that automatically supplies water to extinguish the fire. The GPS module provides accurate location information to facilitate emergency response for authorities.

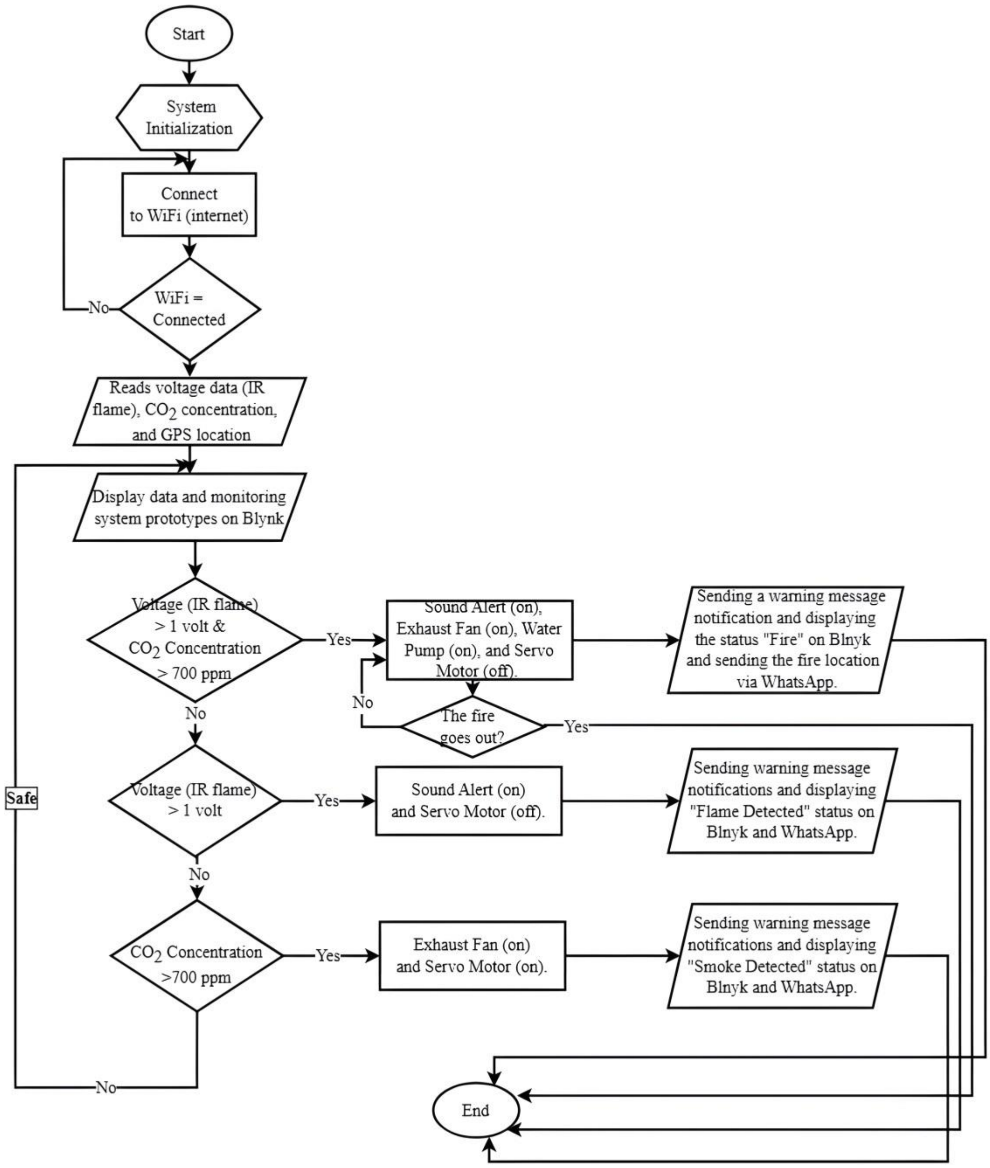


Fig. 3. Flowchart of system prototype

Figure 3 is a flowchart of the system device design. This design process was created using the Arduino IDE software application to develop the program that will be uploaded to the Arduino Uno and ESP32 boards, with the design using the Blynk application to create the system's user interface and the WhatsApp application as a medium for warning message notifications. The use of two microcontrollers is due to the need for many analog and digital pins in the system, as well as for serial communication of the system to the internet network. In creating the program on the Arduino Uno and ESP32, the process begins with system initialization to declare which pins are used, and the system will adjust the connection to the internet network using WiFi. After that, it continues with reading the data values from the sensors used, namely the IR flame sensor, which will read the voltage value, and the MQ-135 sensor to read the CO_2 concentration (smoke) value on the prototype. The system will also track location using a "GPS" module installed in the system device.

This system has automatic control. The automatic control is executed through data In its operation, the system has three different handling levels based on the detected conditions. The most serious condition is when the system detects a potential large fire, marked by a voltage above 1 volt and CO_2 concentration above 700 ppm. In this condition, the system will activate the sound alarm, exhaust fan, and water pump and turn the servo motor off. Simultaneously, the system sends a "Fire" alert via the Blynk and WhatsApp applications along with the fire location and continues to monitor until the fire is extinguished. The second level is when the system only detects fire (voltage > 1 volt without significant CO_2 increase). In this situation, the system activates the sound alarm and turns the servo motor off, sending a "Flame Detected" notification status via Blynk and WhatsApp. Meanwhile, the third level occurs when only smoke is detected (CO_2 concentration >700 ppm without fire). The system will respond by activating the exhaust fan and servo motor, sending a "Smoke Detected" notification status through both applications. The use of the Blynk and WhatsApp applications ensures that alerts can be quickly received by users through their smartphones. The reading and processing by the Arduino (transmitter) and processed by the ESP32 (reciever).

The prototype system for early detection and home fire extinguishing based on IoT and GPS will be made in accordance with the system design that has been described. The finished system will be tested. If testing has been carried out on the tool, then experiments can be carried out on the research. The last step in engineering research is testing the system that has been developed. This test aims to verify whether all system components operate properly and detect potential errors that may occur in the system. The accuracy of the system is measured by comparing the system measurement results with theoretical calculations [19].

Data collection in this study will begin by comparing the measurement results of the physical quantities of the developed tools compared to the readings of standard measuring instruments. Using this data, the accuracy of the device will be determined. By measuring each physical quantity repeatedly, the accuracy of the device will also be determined. To determine the level of accuracy, the accuracy measurement data must be processed using Equation (1).

$$A = \left(1 - \frac{Yn - Xn}{Yn}\right) x\ 100\% \qquad (1)$$

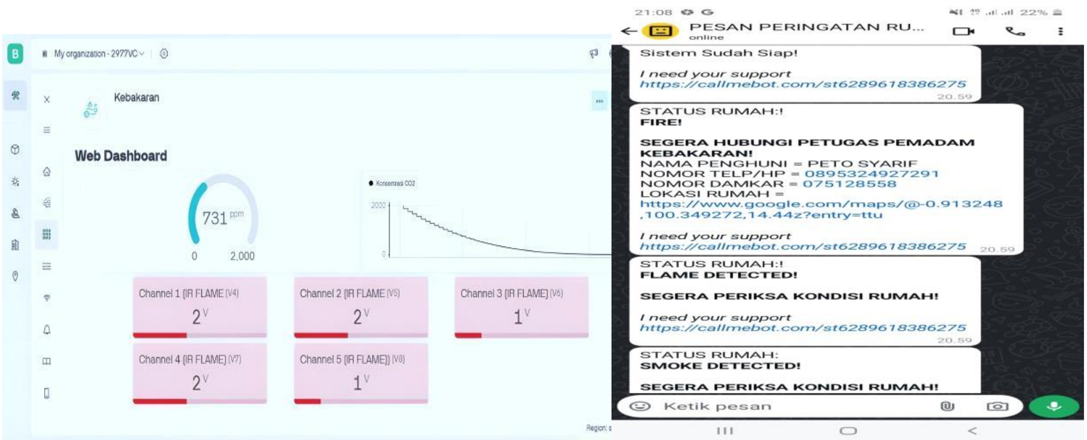
Precision of this system can be determined using Equation (2).

$$P = \left(1 - \frac{Xn - \bar{X}}{\bar{X}}\right) x\ 100\% \qquad (2)$$

III. RESULTS AND DISCUSSION

The research results obtained in this research on a prototype system for early detection and home fire extinguishing based on IoT and GPS are performance specifications and design specifications. Performance specifications are detailed definitions of each part of the system, from the shape and size of the hardware, how the electronic components are used, and the function of each part [20].

The measurement results of the system prototype will be displayed on the Blynk application, and the early warning system will be displayed on the WhatsApp application. The following display of the Blynk and WhatAppp applications on the system prototype is shown in Figure 4 below:



(a) (b)

Fig. 4. (a) User interface of monitoring system prototype and (b) Early warning message notification display

In Figure 17 (a), is the display of the early warning notification interface via WhatsApp in the form of a short message regarding the status or environmental conditions of the system prototype, and (b) is the user interface display of fire monitoring data in units (V), air CO_2 concentration monitoring in units (ppm), and real-time graphic data display on Blynk. Monitoring can be done using the user's smartphone and computer devices in real-time.

The prototype system uses two sensors that have different characteristics. These sensors are the IR flame sensor to measure the detection of infrared radiation (fire) in V units (photoelectric effect) and the MQ-135 sensor to measure air CO_2 concentrations in ppm units. In measuring the system prototype, we carried out sensor characterization testing by comparing the output reading values on the sensor with standard instruments. Characterization measurements can be seen in Figure 5 and Figure 6.

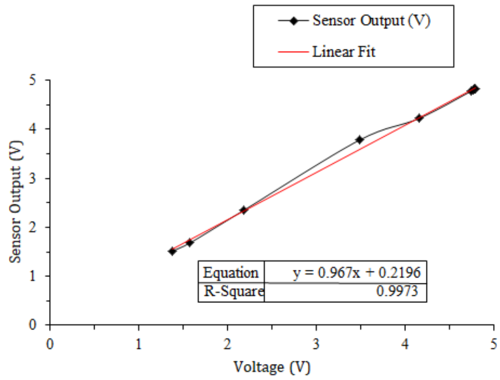


Fig. 5. Characterization of a voltage (V)

In Figure 5, the characterization of the IR flame sensor in measuring voltage in the system, it is found that the system has very linear properties in response to voltage changes on fire detection. The system gives a reading that is very close to the actual voltage. The linearity graphic analysis reinforces this, showing a good linear curve with an R-squared value of 0.9973, close to 1. This indicates that the readings from the system prototype are close to the standard tool readings.This characterization The results illustrate the system's ability to provide highly accurate and linear readings in measuring voltage parameters in fire detection.

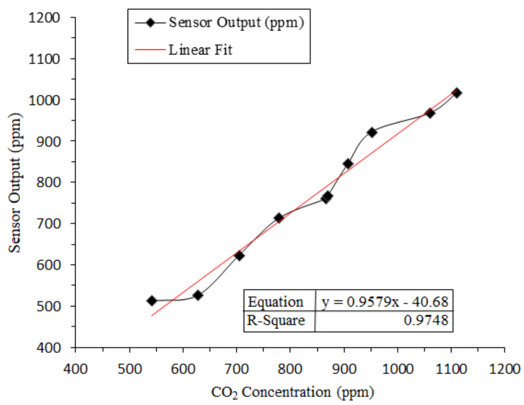


Fig. 6. Characterization of a CO_2 concentration (ppm)

In Figure 6, the characteristics of the MQ-135 sensor in measuring CO_2 concentration in the system, it is known that the system has very linear characteristics in responding to changes in CO_2 concentration during smoke detection. The system provides readings that are very close to the actual CO_2 concentration. The linearity graphic analysis reinforces this, showing a good linear curve with an R-squared value of 0.9748, close to 1. This indicates that the readings from the system prototype are close to the standard tool readings. The results of this characterization illustrate the system's ability to provide accurate and linear readings in measuring CO_2 concentration parameters in smoke detection.

Design specifications were obtained from the results of measurements carried out during the research. This data is obtained after first calibrating the system from the results of sensor characterization measurements. This can be seen in Figures 5 and 6. In this research, the design specifications consist of precision, precision, actuator testing, and early warning system indicator testing on a prototype system for early detection and home fires extinguishing based on IoT and GPS. Data on the accuracy of the prototype is obtained from comparing the value of physical quantities read on standard measuring instruments with the value of physical quantities read on the prototype. The collected data on voltage accuracy (flame) on the prototype 10 times by varying the distance of the fire source every 5 cm. Data on the results of measuring the accuracy of the voltage (flame) on the prototype is shown in Table 1.

Table 1. Voltage Accuracy Measurement Data on System Prototype

Distance (cm)	Standard Tool (V)	Prototype System (V)	Accuracy	Percentage Accuracy (%)	Percentage Error (%)
1	4,75	4,85	0,9789	97,89	2,11
2	4,72	4,82	0,9788	97,88	2,12
3	4,62	4,79	0,9632	96,32	3,68

4	4,60	4,75	0,9674	96,74	3,26
5	3,76	3,89	0,9674	96,54	3,46
6	3,64	3,82	0,9505	95,05	4,95
7	2,84	2,70	0,9507	95,07	4,93
8	2,37	2,44	0,9505	97,05	4,95
9	2,38	2,46	0,9664	96,64	3,36
10	1,55	1,65	0,9355	93,55	6,45
Average			0,9627	96,27	3,93

Table 1 shows the voltage accuracy data on the prototype. The accuracy measurement results have an average percentage accuracy of 96.27%, with the lowest percentage accuracy of 93.55% and the highest percentage accuracy of 97.89%. There is a discrepancy between the voltage accuracy values obtained using the standard tool on the prototype. The average percentage error of measurement is 3.93%, with the lowest percentage error of 2.11% and the highest percentage error of 6.45%. The measurements produced by the system are consistent and have a very small difference with the measurements of standard tools. This shows that the system has a high level of accuracy in measuring voltage.

Collected accuracy data on the air CO_2 concentration of the prototype 10 times by varying the data collection time every 1 minute. Data from the measurement of the accuracy of air CO_2 concentration on the prototype is shown in Table 2.

Table 2. CO_2 Concentration Accuracy Measurement Data on System Prototype

Time (Minute)	Standard Tool (ppm)	Prototype System (ppm)	Accuracy	Percentage Accuracy (%)	Percentage Error (%)
1	518	500	0,9653	96,53	3,47
2	550	535	0,9727	97,27	2,73
3	630	619	0,9825	98,25	1,75
4	674	651	0,9659	96,59	3,41
5	726	703	0,9683	96,83	3,17
6	807	789	0,9777	97,77	2,23
7	856	832	0,9720	97,20	2,80
8	913	898	0,9836	98,36	1,64
9	965	949	0,9834	98,34	1,66
10	1027	1011	0,9844	98,44	1,56
Average			0,9756	97,56	2,44

Table 2 shows data on the accuracy of air CO_2 concentration on the prototype. The accuracy measurement results have an average percentage accuracy of 97.56%, with the lowest percentage accuracy of 97.20% and the highest percentage accuracy of 98.44%. There is a deviation from the results of the accuracy of the CO_2 concentration in the prototype with the CO_2 concentration in the standard tool; the average percentage error of measurement is 2.44%, with the lowest percentage error of 1.56% and the highest percentage error of 3.47%. The measurements produced by the system are consistent and have a very small difference with the measurements of standard tools. This shows that the system has a high level of accuracy in measuring air CO_2 concentration.

The next design specification is the precision of the system. System precision is obtained from repeated measurements of a parameter 10 times under the same conditions. Based on the measurement results, the average value and precision percentage can be analyzed. Obtained voltage precision data on the prototype by taking repeated measurements at a fixed distance of 10 cm from the fire source, measuring the voltage 10 times. Data on the results of measuring the precision of the voltage on the prototype is shown in Table 3.

Table 3. Voltage Precision Measurement Data on System Prototype

Data	Voltage(V)	Precision	Percentage Precision (%)
1	4,85	0,9988	99,98
2	4,85	0,9998	99,98
3	4,84	0,9981	99,81
4	4,85	0,9998	99,98
5	4,84	0,9981	99,81
6	4,88	0,9936	99,36
7	4,84	0,9981	99,81
8	4,86	0,9977	99,77
9	4,84	0,9981	99,81
10	4,84	0,9981	99,81

Average	4,849	0,9981	99,81

Table 3 shows the voltage precision data on the prototype. The precision measurement results have an average precision percentage of 99.81%, with the lowest precision percentage of 99.36% and the highest precision percentage of 99.98%. This shows that the system consistently provides results very close to the actual value in voltage measurement. High average precision and relatively small error values characterize this. Good precision is when the measured values are close to each other with the average value.

Obtained the air CO_2 concentration precision data on the prototype by taking repeated measurements every 1 minute, measuring the air CO_2 concentration 10 times. Data on the results of measuring the precision of the air CO_2 concentration on the prototype is shown in Table 4.

Table 4. CO_2 Concentration Precision Measurement Data on System Prototype

Time (Minute)	CO_2 Concentration (ppm)	Precision	Percentage Precision (%)
1	496	0,9635	96,35
2	494	0,9596	95,96
3	523	0,9841	98,41
4	526	0,9782	97,82
5	518	0,9938	99,38
6	521	0,9880	98,80
7	522	0,9860	98,60
8	511	0,9926	99,26
9	520	0,9899	98,99
10	517	0,9957	99,57
Average	514,8	0,9831	98,31

Table 4 shows the air CO_2 concentration precision data on the prototype. The precision measurement results have an average precision percentage of 98.31%, with the lowest precision percentage of 95.96% and the highest precision percentage of 99.57%. This shows that the system consistently provides results very close to the actual value in voltage measurement. High average precision and relatively small error values characterize this. Good precision is when the measured values are close to each other with the average value.

Tested the actuator by checking its on/off condition according to the predetermined set point. Automatic exhaust fan testing is useful for controlling and removing smoke (CO_2) from fire results (regulating air circulation) to match the ideal state of air CO_2 concentration in the prototype. The test results of the automatic exhaust fan on the prototype are shown in Table 5.

Table 5. Testing of Automatic Exhaust Fan on System Prototype

Parameters	Measured Value	Actuator Condition
CO_2 concentration (ppm)	890 ppm	On
	562 ppm	Off

Based on Table 5, the exhaust fan will turn off when it reaches a CO_2 concentration of 562 ppm, and the exhaust fan will turn on when it reaches a CO_2 concentration of 890 ppm because it exceeds the set point value of above 700 ppm. The actuators used in the prototype system can work well because the actuators have worked in accordance with the set points that have been set.

Automatic water pump testing is useful for spraying water when a fire is detected so that the fire can be extinguished. The test results of the automatic water pump on the prototype are shown in Table 6.

Table 6. Testing of Automatic Water Pump on System Prototype

Parameters	Measured Value	Actuator Condition
Flame (voltage) and CO_2 concentration (ppm)	4,82 V and 780 ppm	On
	0,86 V and 515 ppm	Off

Based on Table 6, the water pump condition turns off when the voltage and CO_2 concentration reach 0.86 V and 515 ppm and the water pump will turn on when the voltage and CO_2 concentration reach 4.82 V and 780 ppm because it exceeds the set point value is a value above 1 V and 700 ppm. The actuators used in the prototype system can work well because the actuators have worked in accordance with the set points that have been set.

Next, Automatic servo motor testing is useful for driving and controlling the direction of rotation of IR flame sensor detection such as radar. The test results of the servo motor on the prototype are shown in Table 7.

Table 7. Testing of Automatic Servo Motor on System Prototype

Parameters	Measured Value	Actuator Condition
Flame (voltage)	0,92 V	On
	3,89 V	Off

Based on Table 7, the servo motor turns off when the voltage reaches 3.89 V. The motor turns on when the voltage drops to 0.92 V, which is below the set point value of 1 V. The actuators in the prototype system are functioning properly as they operate according to the predetermined set points.

The final test, the working test of the fire early warning system, is a crucial stage in this research, which aims to evaluate the system's response to fire events and observe the performance of the prototype in situations close to real conditions. To ensure the reliability and consistency of the system, a series of three tests were conducted under three different conditions: fire (flame and smoke present), flame and smoke present. The tests included three main features of the system, namely speakers (sound alert), alert notification via WhatsApp, and "GPS"-based location information. The test results of the fire early warning system on the prototype are shown in Table 8.

Table 8. Fire Early Warning System Test on System Prototype

No.	Condition	Speakers (Sound Alert)	WhatsApp Alert Notification	GPS Location	Delay (Seconds)
1		On	sent	sent	15
2	Fire	On	sent	sent	13
3		On	sent	sent	11
4		On	sent	-	8
5	Flame	On	sent	-	8
6		On	sent	-	7
7		-	sent	-	6
8	Smoke	-	sent	-	5
9		-	sent	-	5

Description: (-) = inactive/not sent/not available.

Table 8 illustrates the results of testing the work of the fire early warning system on the prototype. This table contains information about the status of the speaker (sound alert), warning notification (WhatsApp message), location, and delay for each condition tested in fire, fire, and smoke conditions. In fire conditions, the system will respond by issuing a sound alert (smartphone speaker), sending an alert notification via WhatsApp, and providing location information via "GPS", with overall system activation requiring an average delay of 13 seconds. In fire conditions, the system will issue a warning sound, send a warning notification, but not provide location information, with overall system activation requiring an average delay time of 9 seconds. While in the presence of smoke, the system will only send a warning notification without issuing a warning sound or providing location information, with overall system activation requiring an average delay time of 5.3 seconds. Overall, the fire early warning system in this prototype has worked well by providing different responses to various conditions that may occur according to the software design of the system with a delay time for overall system activation between 5 to 15 seconds.

In this research, the system is designed using a GPS tracker integrated with Google Maps to track the location of fires in real-time and accurately. This integration can reduce the time to find the location or route of fire travel by firefighters, which is an advantage over previous research that does not have GPS integration. This system uses a 5-channel IR flame sensor that has the advantage of a wider viewing angle in detecting fires compared to previous research that still uses a 1-channel IR flame sensor with limited fire area detection [21]. In addition, the system is equipped with a sound alert feature from a smartphone speaker instead of a buzzer that functions to provide output in the form of a special ringtone for early warning in the house when the system detects a fire. Additional features that support this system include sending emergency alert message notifications to users via WhatsApp and monitoring/user interface features via the Blynk app. The combination of these features provides a comprehensive alert system that is easily accessible to users. The results show that this prototype system has good accuracy and precision, as can be seen in Table 1-4. Meanwhile, the early warning system shows good responsiveness with the response time listed in Table 8, which is faster than previous studies using a single sensor and without GPS integration. The main advantage of this system lies in the use of multi-sensors (5-channel IR flame and MQ-135) as well as real-time notification via WhatsApp and GPS-based location tracking, which successfully overcomes the limitations of previous studies. In addition, actuators such as water pumps and exhaust fan work well according to the set point data, thus ensuring effective automatic fire extinguishing handling, which can be seen in tables 5 and 6. This is in line with previous studies, but with a significant improvement in response speed, making the system more reliable for home fire mitigation. The development of this IoT- and GPS-based system is expected to help prevent and minimize the spread of house fires and reduce casualties and property losses due to fire disasters through more effective early detection.

IV. CONCLUSION

From the research results, it is concluded that the prototype system for early detection and home fire extinguishing based on IoT and GPS has been successfully designed with a performance that shows that the system has a high linearity value, accuracy, and good precision. The system shows high linearity characteristics with an average voltage measurement accuracy of 96.27% and an average CO_2 concentration measurement accuracy of 97.56%. The precision of the system is also very good, with the average voltage measurement reaching 99.81% and CO_2 concentration 98.31%. This prototype is able to provide a fast response in detecting fire hazard conditions with a response time between 5 and 15 seconds. The actuators used in the prototype system have worked well because the actuators work according to the set points that have been set. The system has the ability to detect fire and smoke using IR flame and MQ-135 sensors. The system successfully implements real-time notification features via WhatsApp and location tracking using "GPS", enabling users and emergency authorities to immediately respond to potential fires, as well as activate automatic warning and extinguishing systems.

REFERENCES

[1] M. Nurrachman, "Prototype of microcontroller-based earthquake and fire detection system in buildings," *J. Tek. Elektro dan Sains*, pp. 1–4, 2020.
[2] B. Febby Rahmatullah, Ayusta Lukita, "Disaster Response Village," 2020.
[3] K. I. Ismara, "Fire Safety," *Univ. Negeri Yogyakarta*, pp. 29–31, 2019, [Online]. Available: http://mat.fmipa.uny.ac.id/sites/mat.fmipa.uny.ac.id/files/download/Pedoman K3 Kebakaran.pdf (diakses pada 20 Mei 2020)
[4] I. Husna, "Analysis of the Fire Emergency Response System in the Container Terminal Stacking Field of PT. Nilam Port Terminal Indonesia Tanjung Perak Surabaya DIPLOMA PROGRAM STUDY OF MARKETING MANAGEMENT," *Skripsi Univ. Hang Tuah Surabaya*, 2020.
[5] Ananda Muhamad Tri Utama, "Work Effectiveness of the Fire Fighting Task Force at the Agam Regency Fire and Civil Service Unit," vol. 9, pp. 356–363, 2022.
[6] N. S. K, A. Robbani, E. N. P, and R. A. P, "Nganjuk Based on Android and Website Using Prototype Method Design of E-Damkar Application in Nganjuk Regency Based on," *Pros. Semin. Nas. Teknol. dan Sist. Inf.*, pp. 696–705, 2023.
[7] Dinas Pemadam Kebakaran Kota Batam, "Fire and Non-Fire (Rescue) Incident Report 2020," p. 54, 2020.
[8] B. Artono and R. G. Putra, "Application of Internet Of Things (IoT) for Light Control Using Web-Based Arduino," *J. Teknol. Inf. dan Terap.*, vol. 5, no. 1, pp. 9–16, 2019, doi: 10.25047/jtit.v5i1.73.
[9] T. Iqbal, "Design of Prototype GPS Tracker via SMS Based on Arduino Nano Microcontroller Abstract," vol. 3, no. 1, pp. 11–25, 2023.
[10] U. A. Saputro and A. Tuslam, "Internet Of Things Based Fire Detection System With Warning Messages Using NodeMCU ESP8266 And ThingSpeak Platform," *J. Infomedia*, vol. 7, no. 1, p. 24, 2022, doi: 10.30811/jim.v7i1.2958.
[11] M. N. Fachry, H. S. Syah, and S. Sungkono, "Design of a Fire Extinguishing System Based on the Internet of Things," *E-Link J. Tek. Elektro dan Inform.*, vol. 16, no. 2, p. 65, 2021, doi: 10.30587/e-link.v16i2.2956.
[12] A. Napu, O. Kembuan, and K. Santa, "Fire Early Warning and Handling System Based on Internet Of Things (IoT)," *JOINTER J. Informatics Eng.*, vol. 3, no. 01, pp. 10–16, 2022, doi: 10.53682/jointer.v3i01.45.
[13] Z. R. Ritonga and N. Nopriadi, "Design of an Automatic Fire Extinguishing and Notification System Based on the Internet of Things (Iot)," *Comput. Sci. Ind. Eng.*, vol. 9, no. 3, 2023, doi: 10.33884/comasiejournal.v9i3.7699.
[14] A. Nadila, A. Abdullah, and P. Y. Utami, "Fire Detection Prototype and Potential Gas Leak Using Wemos D1 Mini Based on Esp8266 Through Telegram and Whatsapp Notification," *Digit. Intell.*, vol. 3, no. 2, p. 1, 2023, doi: 10.29406/diligent.v3i2.4739.
[15] L. Kirkup, *Experimental Methods for Science and Engineering Students: An Introduction to the Analysis and Presentation of Data*. 2019. doi: 10.1017/9781108290104.
[16] Y. Triawan and J. Sardi, "Automation System Design for Aquascape Based on Arduino Nano

Microcontroller," *JTEIN J. Tek. Elektro Indones.*, vol. 1, no. 2, pp. 76–83, 2020, doi: 10.24036/jtein.v1i2.30.

[17] A. Anantama, A. Apriyantina, S. Samsugi, and F. Rossi, "Electricity Consumption Monitoring Device for Electronic Equipment Based on Arduino Uno.," *J. Teknol. dan Sist. Tertanam*, vol. 1, no. 1, p. 29, 2020, doi: 10.33365/jtst.v1i1.712.

[18] S. Nirwan and H. MS, "Design and Development of an Application for a Prototype System to Monitor Electricity Consumption of Electronic Equipment Based on Pzem-004T," *Tek. Inform.*, vol. 12, no. 2, pp. 22–28, 2020.

[19] Randy, N. Yendri Sudiar, A. Fauzi, and L. Dwiridal, "Analysis of the Comfort Level of Climate in the Padang Coastal Tourism Area Using the Holiday Climate Index (HCI) Method," *J. Clim. Chang. Soc.*, vol. 1, no. 1, pp. 1–11, 2023, doi: 10.24036/jccs/vol1-iss1/3.

[20] I. Tri Handini, Y. Yulkifli, and Y. Darvina, "Design and Build of an Air Pressure Measurement System Using DT-Sense Barometric Pressure Based on the Internet of Things with a Smartphone Display," *J. Teor. dan Apl. Fis.*, vol. 8, no. 1, pp. 1–10, 2020, doi: 10.23960/jtaf.v8i1.2257.

[21] J. Yahya, N. Rahaningsih, and R. Danar, "Performance Analysis of Arduino Uno-based Fire Early Detection System Using 5-Channel Flame Sensor and Emergency Symbol," *JATI (Jurnal Mhs. Tek. Inform.*, vol. 8, no. 1, pp. 437–444, 2024, doi: 10.36040/jati.v8i1.8458.