International Journal of Electrical Engineering, Mathematics and Computer Science
Volume. 2, Nomor. 1 Year 2025
e-ISSN: 3048-1945, p-ISSN : 3048-1910, Page 01-16
DOI: https://doi.org/10.62951/ijeemcs.v2i1.136
Available online at: https://international.arteii.or.id/index.php/IJEEMCS

Design Of An Early Warning System For Fire Based On The Internet Of Things (IOT) Using Nodemcu Esp8266

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Abstract: *Fire is one of the incidents that disturbs homeowners because of the fire that will drain property and can claim lives when there is a lack of anticipation and minimal ignorance of the incident, such as when a fire occurs there is no early warning to the homeowner, this is also a cause of fire. The cause of the fire can be caused by a gas leak, electrical short circuit or caused by the community itself. Based on these problems, a solution is needed to create a safety system technology to be applied to the home kitchen, namely the design of an early detection system for fires based on the Internet Of Things (IoT) using ESP8266 which is useful for monitoring kitchen conditions and will automatically send a notification of the kitchen condition if the sensor reads an incident. The Hardware Design uses several tools consisting of ESP8266, Arduino R3. Jumper Cables, Fire Sensors, MQ-2 Gas Sensors, Mini Fans, Mini Water Pumps, Relays, Buzzers. and for the software design using Arduino IDE for system programming and Blynk as an application to display notifications. The designed system will be tested using black box testing which is used to determine whether the designed system will meet the specified parameters or not, and the results of the design state that the system is in accordance with the parameters used.*

Keywords: *Internet Of Things, Fire Sensor, Gas Sensor.*

1. INTRODUCTION

Fire is one of the incidents that disturbs homeowners, because with the fire, the impact that will be received is draining property and can claim lives when there is a lack of anticipation and minimal ignorance of the incident, such as when a fire occurs there is no early warning to the homeowner, this is also a cause of fire. The cause of the fire can be caused by a gas leak, electrical short circuit or caused by the community itself [1].

The use of gas fuel (LPG) which is the main need in household activities consists of a mixture of flammable materials and consists of hydrocarbon gases and most often uses propane, butane, and propylene content. In its use, LPG gas is also one of the risks of leaks in the cylinder or LPG pipe, so that if exposed to fire it can cause a fire very quickly, besides that it can also affect the health of the body if it is inhaled too often by the body. LPG cylinders will not explode, but it is gas that is trapped due to leaks that are trapped in a closed room and get small sparks that make it explode, LPG gas leaks in the kitchen will be very dangerous because LPG gas will be heavier if it is in the air [2]. Based on these problems, a solution is needed to create safety system technology to be applied to home kitchens, namely the design of an early detection system for fires based on the Internet Of Things (IoT) using ESP8266 which is useful for monitoring kitchen conditions and will automatically send a notification of the condition of the kitchen if the sensor reads an incident. Several studies have been developed in monitoring room

Received: December 04, 2024; Revised: December 18, 2024; Accepted: January 11, 2025; Online Available:

conditions using a sensor system with various measurement parameters, one of which was conducted by Researcher Amali, Achmad Fariid., Internet Of Things (IoT) Based Fire Detection System With Arduino Devices [3]. The novelty of this system design is by adding an action circuit from both sensors and providing notifications on the cellphone. This research will focus on designing an Internet Of Things (IoT) Based Fire Detection System Using ESP8266 to monitor room conditions and send notifications to cellphones. The system will be designed, modeled and undergo system testing.

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2. LITERATURE REVIEW

System

A system is a collection consisting of several elements that interact or are integrated to achieve the objectives of the components or elements so that their scope becomes wider in completing a particular target. System components are a characteristic of a system, input, output, processing, target or objective [4].

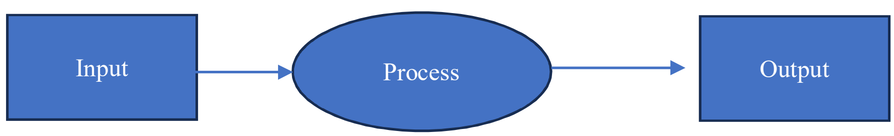

Figure 1. System

(Source: Soufitri, 2023)

A system can be achieved well if there is supervision that is useful for supervising the implementation of achieving goals consisting of input data supervision, output data supervision, and control over system operations. Input is a subsystem that functions to receive input data consisting of input sources, input frequency and type of input data, then the input will later be processed consisting of searching, repairing, filling, other groupings, the results of this process are called output.

Internet Of Things

Internet Of Things(IoT) was first introduced by a British technology pioneer who co-founded the Auto-ID Center at the Massachusetts Institute of Technology, Kevin Ashton in 1999. Internet Of Things (IoT) is defined as a global infrastructure to meet the information needs of society, which allows for advanced services with both physical and virtual interconnections based on existing and developments in information and communication technology (ICT). Another definition explains that the Internet Of Things (IoT) is a set of sensors that are connected to the internet and behave like the internet by opening open connections at all times, and sharing data freely and enabling unexpected applications, so that computers can understand the world around them and become part of human life [5].

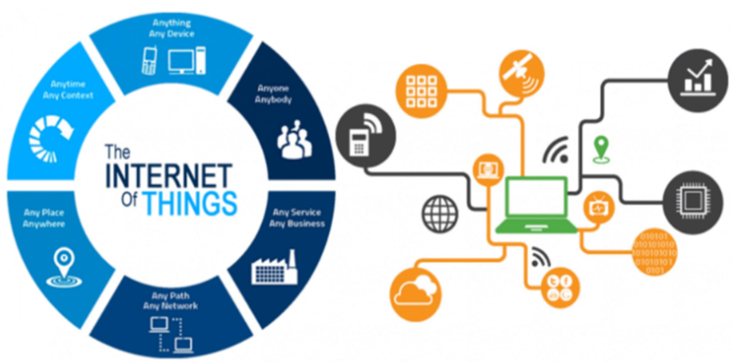

Figure 2. Internet Of Things System

(Source:https://digitalbisa.id)

The image above shows that the IoT cloud can interact with various fields, the need for data and human communication will continue to emerge from various technologies, with the existence of IoT it can make it easier for humans to carry out their activities by using electronic equipment, control systems and computer networks and the internet that are interconnected will be able to help humans create creative ideas to create a system to help make it easier for humans to do their work.

Hardware

*Hardware*is a computer device that consists of a series of electronic components in physical form that have their respective functions and tasks so as to produce a complete system that works well [6]. The following are some of the hardware needed in designing a system.

a. NodeMCU 8266

*NodeMCU*is an electronic board based on the ESP8266 chip with the ability to run a microcontroller function and also an internet connection, NodeMcu is also an internet of things platform that has an open source nature. The open source used in this study is ESP8266 which is a derivative module from the development of the IoT platform module that can be studied manually, functionally the ESP8266 module is almost the same as the Arduino module, but the difference is that it is specifically for "connected to the internet". NodeMcu programming can use the Arduino IDE application, by installing the ESP8266 driver, and has 128 kbytes of memory and uses the extendable test operating system (XTOS). The following is the form of the NodeMcu ESP8266 [7].

Figure 3. NodeMCU 8266
(Source: Google)

b. Buzzer

Buzzer or alarm is an electronic component that is still in the transducer family, this tool can change electrical signals into sound vibrations. The advantages of this tool are its cheaper price and easy to apply to electronic circuits. How this tool works if there is an electric voltage flowing in the circuit, there will be a mechanical movement in the tool that changes electrical energy into sound energy that can be heard. The following is a picture of a buzzer or alarm tool [7].

Figure 4. Buzzer
(Source: Google)

c. Sensor

A sensor is a tool designed to detect something, and has the function of changing mechanical, magnetic, heat, light and chemical variations into a voltage and electric current or in other words the sensor provides a similarity that resembles the eyes, nose, tongue, and hearing which will then be processed by a controller as its brain. The following are the Arduino uno sensors used in this project.

1. *Flame*Sensor

   *Flame*sensor or fire sensor is a sensor that has a function to detect fire or a fire with high accuracy. The size of the flame detected is a flame with a wavelength of 760 nm to 1100 nm. The transducer used in detecting flames is infrared. The working system of this sensor when there is a flame it will emit a number of small infrared lights, these lights will be received by the photodiode (IR Receiver) on the sensor module, then use OP-Amp to perform an inspection and change the voltage on the IR-Receiver, so that when a fire symptom occurs, the output pin (DO) will provide 0V (LOW) and if there is no fire, the output pin will be 5V (HIGH). The following is a picture of the fire sensor [8].

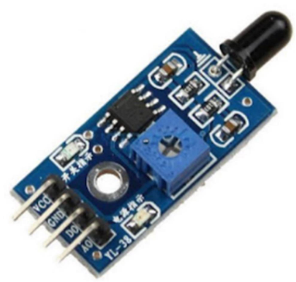

Figure 5. Flame Sensor
(Source: Google)

2. *Sensor*MQ-2

   The MQ-2 sensor is one of the sensors that has high sensitivity to smoke, this sensor is used as a tool to distinguish the concentration of flammable gas, the main element in this sensor is SnO2 with low conductivity of clean air assuming there is a release of gas the sensor conductivity will be high and every increase in gas focus. This sensor can recognize the concentration of flammable gas in the air and smoke, then the result is a simple voltage with a focus size ranging from 300 Ppm - 10.00 Ppm and can work at temperatures from 200oC - 500oC and consumes a current of less than 150 mA at a voltage of 5V. This sensor can detect the concentration of flammable gas in the air where the output is in the form of analog voltage and this tool can operate at temperatures from -20 oC to 50 oC. The following is a picture of the MQ-2 sensor module [8].

Figure 6. Gas Sensor
(Source: Google)

Software

*Software*is a collection of several programs that can be used to run a computer or certain applications. This research requires software programming and wiring design. The following is the software needed including [9].

1. Arduino IDE
   Arduino IDE is a software used to write programs on the Arduino board and compile them into binary and upload them to the microcontroller memory.
2. *Fritz*
   Fritzing is free software used by designers, artists, and electronics hobbyists to design various electronic devices.
3. *Blynk*
   *Blynk*is an application service used to control microcontrollers from an internet network.

3. RESEARCH METHODOLOGY

The research methodology used is a qualitative research method where the research is conducted using primary data in the form of observation data by conducting observations on the designed system, and experimental data to determine whether the designed system can meet expectations or not.

Basic System Architecture

Basic system architecture of early warning system for fireswhich uses a microcontroller with an automatic system that can be seen in Figure 1, the tools that have been connected to the ESP8266 will later be connected to a laptop using a USB cable so that the microcontroller can get power and the connected tools can be connected properly. System programming is done on the Arduino IDE software to create programming syntax and logic so that the system can work as expected, such as determining the pinout on the ESP8266 and using the library needed by blynk as a collection of ready-to-use codes, and designed simply to make it easier for users to implement the code. After the programming has been designed, the interaction between the ESP8266 and the cloud allows the interaction to exchange information data, the data sent from the ESP will be stored on the blynk cloud so that later the data will be sent to the blynk application and then processed to display a warning notification that can be seen on the user's cellphone screen.

Figure 7 Basic System Architecture

System Requirements Analysis

System requirements analysis is an analysis needed to determine the requirements specifications of the system to be designed, namely an IoT-based fire early warning system which can be seen in Figure 2. The requirements of this system are divided into three parts, namely input requirements, process requirements, and output requirements.

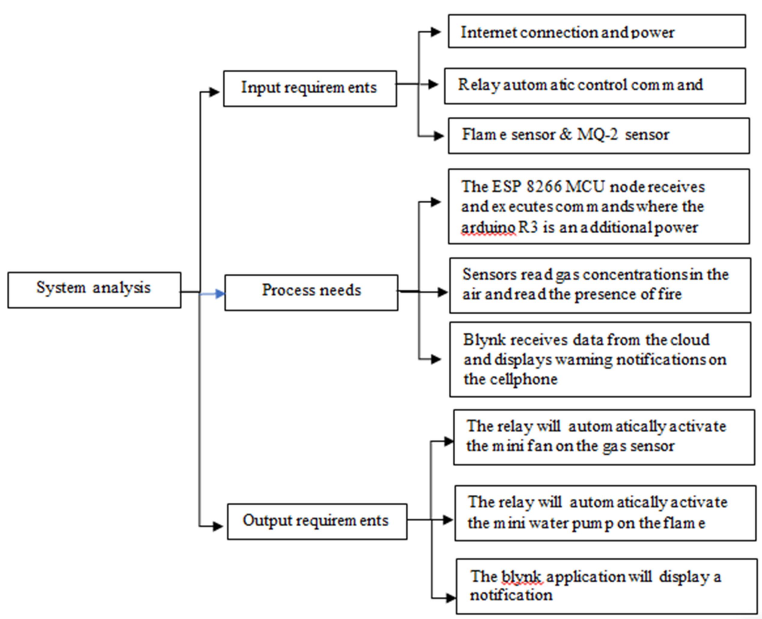

Figure 8 Arduino System Requirements Analysis

Input Requirements

Input requirements are the initial requirements needed in designing a system, in this study input requirements are divided into three parts including the first requirement, namely internet connection and power as the core of the system to work, the second requirement is the automatic control command on the relay so that it can disconnect and connect the electric current to the mini fan and mini water pump so that it can work according to the commands made based on the results of sensor readings, and the third requirement, namely the flame sensor and gas sensor, is the system requirement to be able to work to detect fire and gas content in the air.

Process Requirements

Process requirements will explain how a system can work, process requirements are divided into three parts, starting from the first requirement, namely the NodeMCU ESP8266 as a system driver or microcontroller that receives and sends data from input requirements, the second requirement is that the sensor reads the concentration of gas in the air and reads the presence of fire, the results of the readings of the two sensors will be sent to the cloud via an internet connection, and later will be stored as information, the third requirement is that the blynk application receives data from the cloud and will display notifications on the cellphone

Output Requirements

The output requirements are divided into three parts, namely the first requirement, the relay will automatically activate the mini fan on the gas sensor, in this case if the gas sensor can read the gas concentration that exceeds the specified threshold, the mini fan will move automatically, the second requirement, the relay will automatically activate the mini water pump on the flame sensor, in this case if the fire sensor can read the presence of fire light that exceeds the specified threshold, the mini water pump will move automatically, and the third requirement is that the blynk application will display a notification, in this case the data that has been sent by the ESP8266 will be received by blynk and will carry out its task of giving a warning to the cellphone.

Device Design

The design of an early warning detection system device for fires based on the internet of things is the most important thing in this study, because it aims to understand wiring and make it easier when assembling hardware devices, in this case the design of the device is divided into two parts, namely hardware device design and software device design.

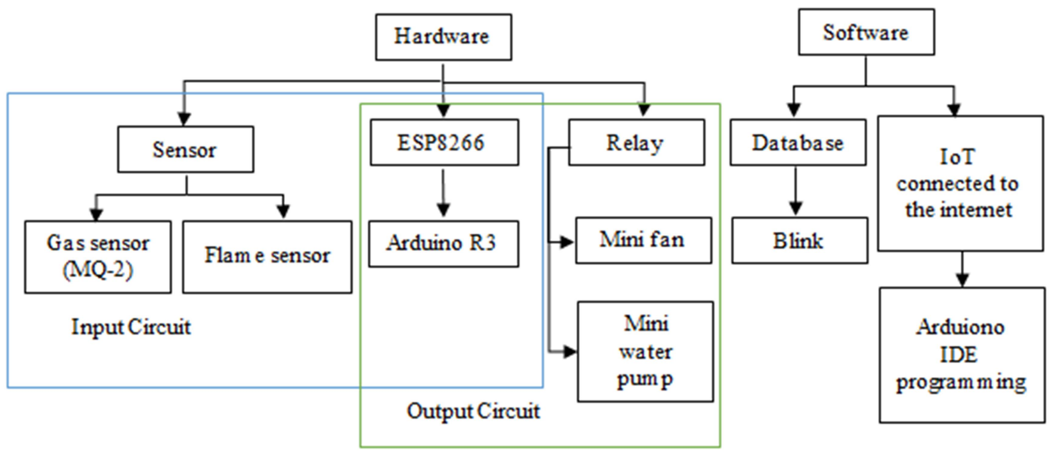

Figure 9 Device Design

Based on the image above is the hardware design and software design, in hardware design several tools are needed including sensor tools, microcontrollers, relays, mini fans, and mini water pumps, the input circuit is a design to connect the two sensors to the microcontroller, and the output circuit is a design to connect the relay to the microcontroller to activate the mini fan and mini water pump. The software design consists of a database and internet connection, the database is needed by the blynk application to be able to display notifications, and the internet is needed in programming the arduino IDE and is also a core requirement for blynk to run.

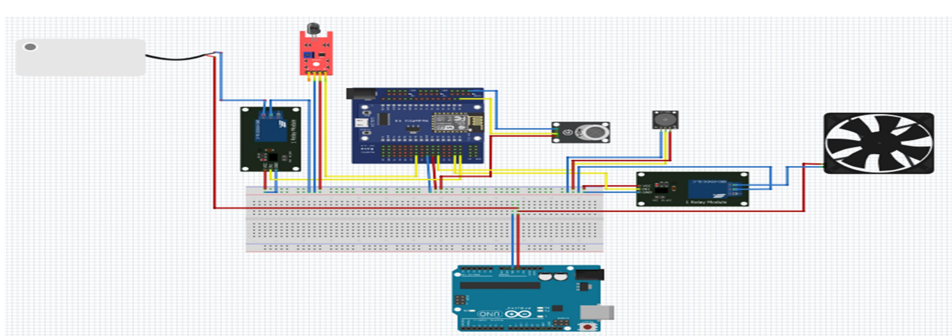

Figure 10 System Design

System Testing

System testing is a level of testing that is carried out comprehensively towards the end of a cycle in developing software. In this study, system testing was divided into 3 stages, namely testing on fire sensors, testing on gas sensors, and testing the functionality of the system.

a. Flame sensor testing

The test carried out on the fire sensor is to test how accurately the sensor can receive fire light in a fire condition that is given a distance from the condition of a large flame.

b. Gas sensor testing

The test carried out on the gas sensor was to test the accuracy of the sensor in reading the air conditions containing gas, which was given a distance in the experiment using a gas lighter.

c. System functionality testing

In testing the system functionality, a method is used, namely black box testing, where testing is carried out on two sensor systems, namely fire and gas.

4. RESULTS AND DISCUSSION

System Test Results

System testing is a cycle in device development that has a role to help ensure that the designed system not only meets technical specifications, but the system can function properly in testing.

Flame Sensor Testing

The fire sensor has a working principle by utilizing the optical method working system or in other words utilizing the reflection and refraction properties of light so that it is able to detect the presence of sparks as an early sign of fire so that in this case the sensor does not need time to detect the presence of fire because the device contains a phototransistor that is sensitive to infrared light produced by fire, the smaller the fire created when it is brought closer to the sensor, the sensor will be able to easily detect the occurrence of fire, if the fire source is large and the distance to the fire sensor is far, the fire sensor will also easily read the presence of fire. The following is a test image of the fire sensor.

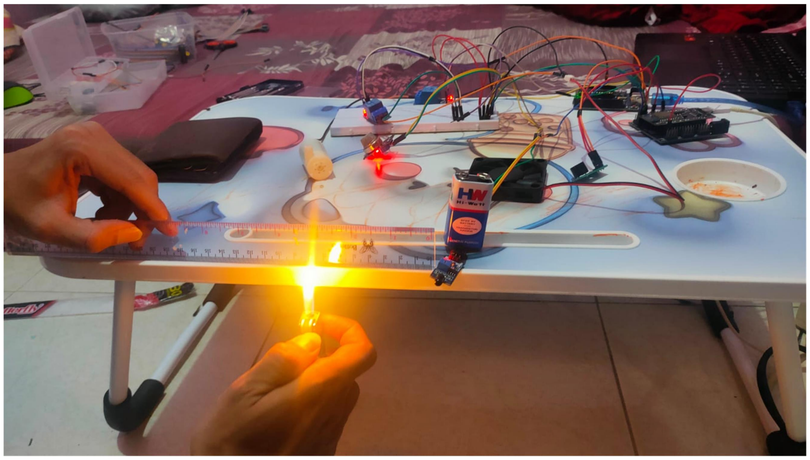

Figure 11 Flame Sensor Testing

Testing on the fire sensor was carried out using a gas lighter to help the sensor testing simulation process. So it can be concluded that this system will detect the presence of fire when measured at a certain distance using a ruler, the fire produced by the lighter is made in large conditions with a distance on the sensor ranging from 1-50 cm. The following is a table of the results of the fire sensor test.

Table 1 Flame Sensor Test Results

No	Distance	Sensor Indicator	*Mini Water Pump*	Buzzer	Room Status	Blynk Notifications
1	5 cm	Light up	Active	Active	There is Fire	There is
2	10 cm	Light up	Active	Active	There is Fire	There is
3	15 cm	Light up	Active	Active	There is Fire	There is
4	20 cm	Light up	Active	Active	There is Fire	There is
5	25 cm	Light up	Active	Active	There is Fire	There is
6	30 cm	Light up	Active	Active	There is Fire	There is
7	35 cm	Light up	Active	Active	There is Fire	There is
8	40 cm	No flame	Not active	Not active	Normal	No
9	45 cm	No flame	Not active	Not active	Normal	No
10	50 cm	No flame	Not active	Not active	Normal	No

Based on the table above, it can be concluded that when the gas lighter ignites a large flame, the sensor indicator will read the presence of fire at a distance of 5 to 35 cm and the sensor does not read the presence of fire at a distance of 40 to 50 cm, this can be seen through the output on the Arduino IDE that the fire sensor reading will produce a digital value, namely 1 and 0, where the value 1 means "LOW" and the value 0 means "HIGH", when the fire sensor successfully identifies at a distance of 5-35 cm, it will provide the information "There is Fire!" and the output in the form of a mini water pump and buzzer that lights up, while the distance of 40-50 cm the output does not light up and the room status is normal.

Gas Sensor Testing

The gas sensor consists of a heating element and a sensor layer made of SnO2 (tin dioxide) which is very sensitive to gas, how the gas sensor works, when the sensor is heated the heating element will heat the tin dioxide layer, when flammable gas is around the sensor, the concentration of the gas will cause a change in the resistance of the SnO2 layer. The following is a picture of a gas sensor test.

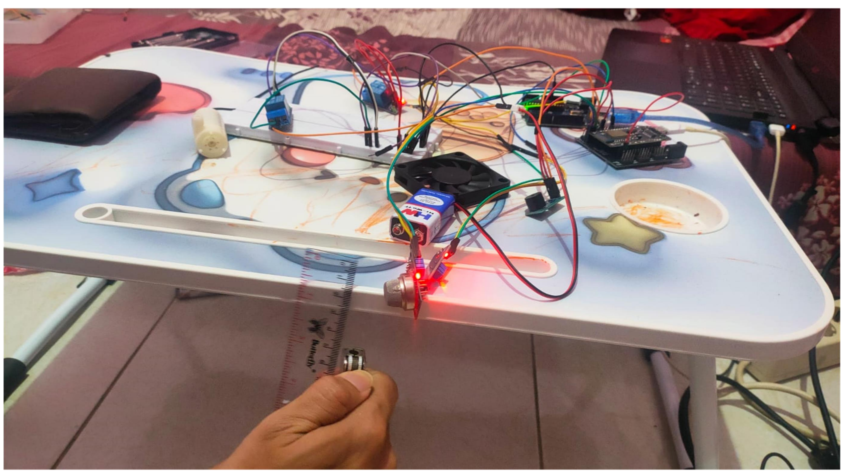

Figure 12 Gas Sensor Testing

In this test, a gas lighter is needed to help the gas sensor test simulation process, where the gas sensor will be very good at reading conditions where there is no air flowing in a room, in other words the gas sensor will easily receive information if the room is airtight and there is no air circulation, the greater the gas contained in the air or that comes out of the gas lighter, the greater the Ppm unit received and if the gas is smaller, the Ppm unit will also be small, and it takes a long time to sound the buzzer and turn on the mini fan. The following is a table of test results from the gas sensor.

Table 2 Gas Sensor Test Results

No	Ppm	Sensor Indicator	*Mini Fan*	Buzzer	Room Status	Distance	Time (seconds)	Blynk Notifications
1	109	Light up	Active	Active	There is a Gas Leak	10 cm	5.42 seconds	There is
2	124	Light up	Active	Active	There is a Gas Leak	8 cm	4.21 seconds	There is
3	157	Light up	Active	Active	There is a Gas Leak	6 cm	4.16 seconds	There is
4	305	Light up	Active	Active	There is a Gas Leak	3 cm	1.98 seconds	There is
5	406	Light up	Active	Active	There is a Gas Leak	Near sensor	1.11 seconds	There is

Based on the results of the Conclusion in the table above in 5 experiments with conditions where the gas lighter is given a distance and the gas released is quite large in the five experiments the sensor successfully reads the presence of gas content in the air, so in this case the further the distance of the lighter from the sensor, the more time it will take for the gas sensor to read the presence of gas content in the air, When the sensor indicator is successful, the mini fan and buzzer will be active, and the room status will state "There is a Gas Leak!" Likewise, if the gas sensor cannot receive gas, the mini fan, buzzer will turn off and the room status will be said to be "normal room".

Blynk Notification Testing

Blynk notification testing is a test where the results of the fire sensor and gas sensor readings can be received by the ESP8266 after which the cloud data that has been received will be sent and processed on blynk to display a warning notification in the form of "There is Fire!" and "There is a Gas Leak!" when the sensor is able to read properly, and at the same time when the sensor successfully reads, it will activate an additional action in the form of a mini water pump that releases water and a mini fan that will release the gas content in the air. The following are the notification results on both sensors.

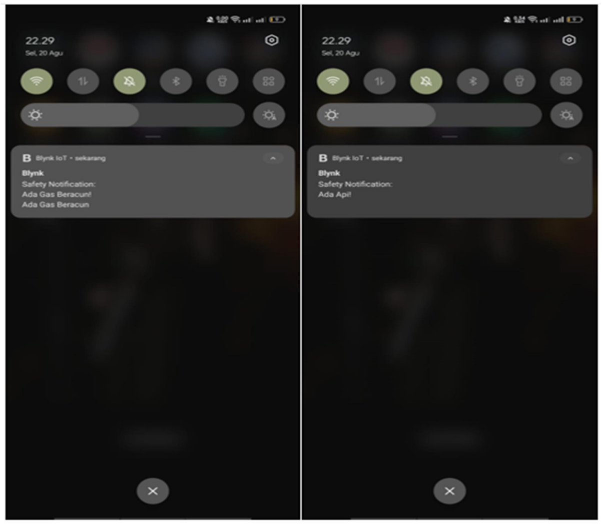

Figure 13 Blynk Notification

System Functionality Testing

System functionality testing is carried out using the black box testing method which aims to determine the function of each tool used in the designed system. The following is a table of system functionality testing results.

Table 3 System Functionality Test Results

No	Sensor	Testing	Desired result	Conclusion
1	*Flame Sensor*	Give a command if the sensor detects and has a value > 0, then the buzzer will automatically sound and the mini water pump will turn on.	The system can read input and produce output, namely it can work when the system successfully reads an event, namely the buzzer, mini water pump and notification can be active and inactive if the sensor does not read the event.	Succeed
		Give a command if the sensor successfully detects fire, then the notification "There is Fire!" appears on the cellphone screen.	Notifications appear on the mobile phone when the sensor reads an event, and there are no notifications if the sensor does not read an event.	Succeed
2	*Gas Sensor*	Give a command if the sensor detects gas content > 100 Ppm, the buzzer will	The system can read input and produce output, namely it can work when the system successfully	Succeed

		automatically sound and the mini fan will turn on.	reads the event, namely the buzzer, mini fan and notification can be active and inactive if the sensor does not read the event.	
		Give a command if the sensor successfully detects gas content, then the notification "There is Gas!" appears on the cellphone screen.	Notifications appear on the mobile phone when the sensor reads an event, and there are no notifications if the sensor does not read an event.	Succeed

4. CONCLUSION AND SUGGESTIONS

Conclusion

The results of the working method of the Internet Of Things-based fire early warning system using NodeMCU ESP8266, starting with designing which is divided into hardware and software, the hardware design will form an integrated electrical design scheme starting from the sensor connected to the ESP8266 microcontroller and connecting the relay, mini water pump, mini fan, and buzzer on the same microcontroller. The software design includes programming on the Arduino IDE and the Blynk Application to obtain the ID and Token to create a notification system. So that the system works when the device is connected to power, the sensor will work to detect an event, and the relay will activate the mini water pump and mini fan and buzzer, finally the results of the sensor reading will send a notification to the cellphone via the blynk application and testing using the black box testing method obtains results with the criteria "Successful" in each test specified on the sensor, so in this case the design can be said to be in accordance with what is desired.

Suggestion

Suggestions are constructive criticisms or contain input that is used to make improvements. The suggestion in this study is that in order for the sensor reading results to be maximized, a sensor tool that has good quality is needed and it is attempted to use the latest type so that the desired output results are appropriate.

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