

Implementation of Building Automation System on Smart Stove to Prevent Fire in Apartment based on Virtuino

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ABSTRACT

The increasing price of land in urban areas makes apartments an alternative housing in urban areas. Apartments as housing cannot be separated from basic human needs, namely eating, drinking, and sleeping. To meet food and drink needs, a stove is definitely needed as a cooking tool. The use of a stove also affects the security of the apartment itself considering the different characters of the residents/tenants. Negligence of the owner or tenant will cause losses for the management or the owner himself. From this problem, a smart stove was created that can detect LPG gas leaks and can provide information to security officers on the same floor using a wifi signal. The system designed uses ESP32 as a system processor and several sensors to support fire detection such as fire sensors and LPG sensors (MQ 2). The use of Virtuino as an IOT (Internet Of Things) device makes it easier for apartment security officers and apartment owners/tenants to monitor LPG gas leaks and the presence or absence of fire and provide early warnings in the form of information sent to Virtuino if a fire occurs in the monitored area.

INTRODUCTION

The increasing price of land in urban areas makes apartments an alternative housing in urban areas (Nilawati et al., 2020). The increasing number of apartments creates its own solution in the layout of the city in the development of urban housing. The increasing number of apartments will be a problem in terms of developers and security for apartment owners (Risquandy et al., 2022). Apartment owners have high demands in terms of security and adequate facilities such as CCTV and security officers on each floor.

However, security in the apartment is not the responsibility of the security officers in the apartment. In fact, the characters of apartment owners and tenants are different. Such as the safety of using stoves in each apartment. Many apartment owners are very careless when leaving their apartments to work. In fact, if there is a gas leak or fire due to the negligence of the apartment owner or tenant, it will harm the owner or the developer of the apartment (Dalimunthe et al., 2021).

Apartments as residences are inseparable from basic human needs, namely eating, drinking, and sleeping. To meet food and drink needs, a stove is definitely needed as a cooking tool. The use of a stove also affects the security of the apartment itself considering the different characters of the residents/tenants. Negligence of the owner or tenant will cause losses to the management or the owner himself. The safety of using a stove is not included in the security



services of the apartment developer and is difficult to detect if there is negligence from the owner or tenant of the apartment itself (Lilipaly et al., 2021).

From this problem, a smart stove was created that can detect LPG gas leaks and can provide information to security officers on the same floor using a wifi signal. The use of wifi signals in apartments can be used to monitor if there is a fire (Pitriyatiar et al., 2021). The easy use of Virtuino is a solution in monitoring gas leaks by security officers on each floor.

The implementation of the Building Automation System on a smart stove is made using several sensors and actuators. The sensors used are fire sensors, MQ 2 sensors (LPG Sensor). The actuators used are valves/solenoids to close the LPG gas and fans to remove the LPG gas and alarms as a sign of danger. The use of ESP32 as a control makes it easy to connect to wifi and virtuino. The use of ESP32 as the main process for monitoring several sensors such as MQ2 (LPG), and fire sensors. The output of this system is an alarm in the form of a buzzer, and solenoid and a display from Virtuino. This is to minimize the occurrence of fires caused by negligence of the owner or tenant of the apartment.

RESEARCH METHODS

This study conducted R&D (Research and Development) to design a smart stove to prevent fire in apartments based on virtuino. The method used is to research various tools available on the market by considering the advantages and disadvantages of each design that has been studied. The research method used can be explained as follows:

1. Literature Study

Literature Study at this stage, a literature study was conducted to study related concepts, such as the Internet of Things (IoT) namely Virtuino, and LPG sensors (MQ 2) and fire sensors. For actuators using solenoids/valves and fans. The literature study also includes a review of previous relevant studies to understand and identify the research gaps being studied.

2. Needs Analysis

This needs analysis stage includes collecting and analyzing the needs of a smart stove system to prevent fires in virtuino-based apartments. Activities carried out include interviews with stakeholders (such as security officers in the apartment area being studied), field observations, and analysis of all existing possibilities. The device is placed in the kitchen area of each apartment and placed near the LPG gas cylinder.

a. ESP32



Figure 1. ESP32 Architecture and Pin Out

ESP32 with a 32-bit processor that has wifi facilities and high speed in processing data from various sensors used in the designed system. ESP32 is used as a control and monitoring of several sensors used in the designed system (Waworundeng et al., 2020). Data from several sensors will

be sent to be displayed on the Virtuino dashboard. By using the Arduino IDE in programming it will make it easier to compile and download the program.

b. Sensor MQ 2

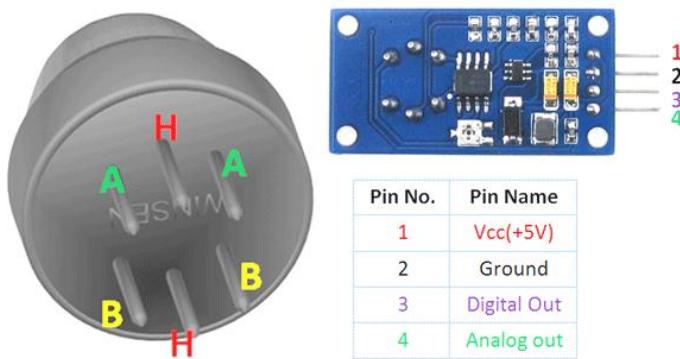


Figure 2. Sensor MQ 2

The MQ 2 sensor is a sensor used to monitor air quality around the stove because this sensor can detect LPG gas and smoke in the event of a fire (Dewi et al., 2020). The use of the MQ 2 sensor in the system is because this sensor has good sensitivity in detecting leaking LPG gas or smoke. The correct placement of the LPG sensor will affect the rapid detection in detecting LPG gas leaks (Fauzi et al., 2020). In addition to the MQ 2 sensor, a fire sensor is also needed in the designed system.

c. Fire Sensor

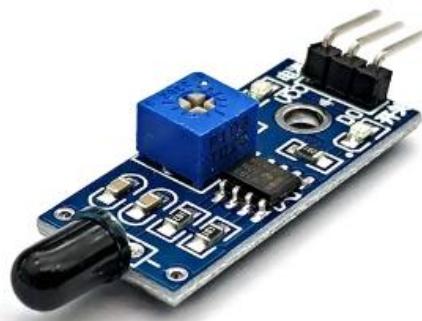


Figure 3. Fire Sensor

The fire sensor functions to detect or ensure the presence of fire in the monitored stove environment. In addition to the MQ 2 sensor that detects LPG in the air, the fire sensor is also tasked with validating the presence or absence of fire around the monitored point (Hutapea et al., 2021). The use of a fire sensor is very important to detect the presence of fire around the stove which will then be the input of the designed system in addition to the MQ 2 sensor. The output of this fire sensor is in the form of a digital voltage, namely 0 if there is no fire, and 1 if it detects fire.

d. Virtuino

Virtuino is an application that can be used on all android smartphone devices. This application can visualize several arduino / ESP32 projects with a widget such as a switch button and display the value of instruments, regulators, and others (Abbassi et al., 2024).

The Virtuino application in this study functions as a data input media and data monitoring in graphical form. Virtuino allows users to create visual interfaces with various widgets such as LEDs, buttons, switches, value displays, instruments, regulators, and others. Virtuino can be used on Android, iOS, and PC devices. This application supports various communication protocols such as MQTT, MQTT5, MODBUS, Web Socket, and HTTP. Virtuino can be used to visualize IoT projects, monitor sensor data, and control connected devices.



Figure 4. Virtuino IoT HMI Platform

e. Selenoid Valve

The solenoid valve in the implementation of the Building Automation System (BAS) smart stove functions to cut off the flow of LPG gas from the stove to the gas cylinder. The solenoid valve works like a tap on a water pipe, only this system is applied to LPG gas. If there is an LPG gas leak or the flame sensor detects a fire, the solenoid valve will close (Istiyanto et al., 2022).



Figure 5. Selenoid Valve

f. Alarm



Figure 6. Alarm

The alarm is used to give a warning in the area where the device is placed. With the presence of the fire alarm, it is expected to make it easier to find out if there is an LPG gas leak that will cause a fire so that security officers can find out about the LPC gas leak that caused the fire in the apartment quickly and efficiently (Yudarsih et al., 2021).

3. System Design

The next stage is to design a system architecture that includes hardware and software components. At this stage, the selection of the appropriate Internet of Things (IoT) technology is carried out, namely Virtuino as well as sensors, actuators, and communication modules, as well as the design of a user-friendly interface using Virtuino.

Figure 7 shows a block diagram of the Implementation of the Building Automation System (BAS) on a Smart Stove to Prevent Fires in Apartments based on Virtuino. The MQ 2 sensor data that reads the LPG levels in the area around the stove and the fire sensor will be sent to Virtuino using Wifi (Husny et al., 2022). The sensor data will be displayed on the dashboard in Virtuino on the cellphone of the apartment security officer on duty. If the sensor data detects an LPG gas leak above the permitted threshold of 200 ppm, the alarm will go off and will send data to Virtuino. The implementation of the Building Automation System (BAS) on a Smart Stove to Prevent Fires in Apartments based on Virtuino works well if the wifi is smooth and there are no network problems.

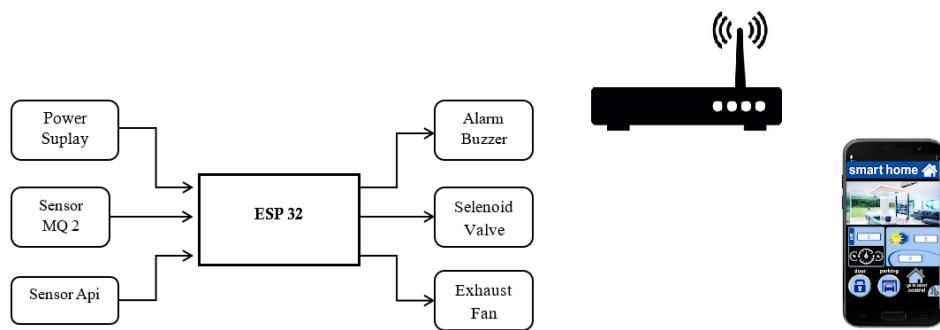


Figure 7. Block diagram of the designed system

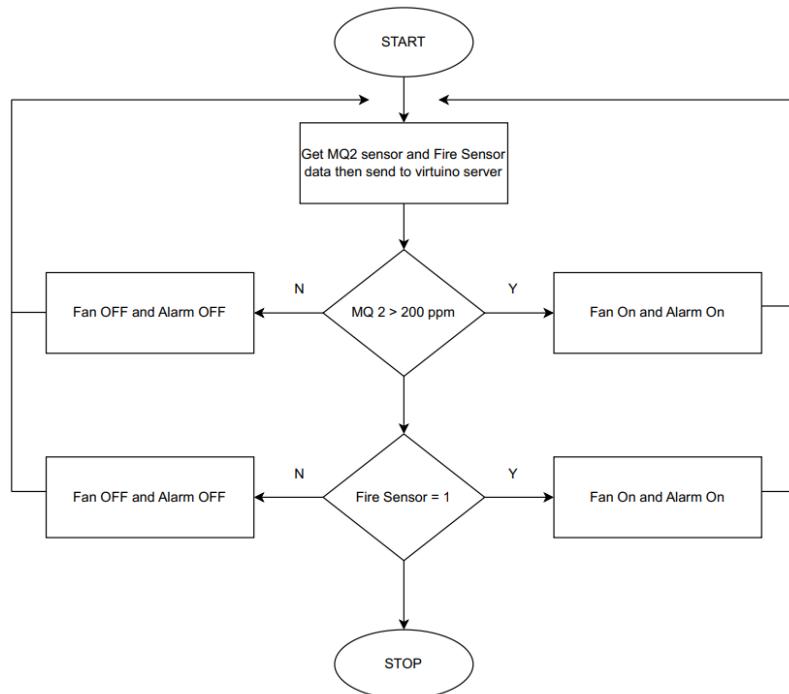


Figure 8. Flowchart of the designed system

Figure 8 shows the flowchart of the Building Automation System (BAS) Implementation on a smart stove to prevent fires in Virtuino-based apartments. MQ 2 sensor data that reads LPG levels in the area around the stove, if the sensor data detects an LPG gas leak at the permitted threshold of 200 ppm, the alarm and fan will turn on and send data to Virtuino. If the fire sensor detects a fire, the alarm and fan will turn on and send data to Virtuino.

4. System Implementation

System implementation after the system design is complete, continued with system implementation both in hardware and software. This stage is the stage of making the Building Automation System (BAS) system tool on the smart stove to prevent fires in Virtuino-based apartments. Then continued with the creation of the Virtuino dashboard to display several monitored sensors placed on the side of the apartment security officer.

a. Implementation of tools placed in the kitchen



Figure 9. Implementation of tools placed in the kitchen

Figure 9 shows a tool that has been designed using several sensors, including the MQ 2 sensor which functions to detect LPG gas as an interpretation of the surrounding air quality and the presence or absence of gas leaks. The fire sensor functions to detect the presence or absence of fire around the tool. ESP32 as the main control of the system created will receive data from the MQ 2 sensor, and the fire sensor, which will then be sent to Virtuino at the monitoring center at the apartment security officer. If there is an LPG gas leak exceeding the threshold of 200 ppm, the nature of the tool will light up, likewise if the fire sensor detects fire around the tool, the alarm will also light up and send data to Virtuino to provide a danger message.

b. Implementation of tools placed in the kitchen

Figure 10 shows the realization of the Building Automation System (BAS) tool on a smart stove to prevent fires in apartments based on Virtuino that was designed. The placement of the MQ2 sensor and the fire sensor is close to the gas cylinder to quickly detect if there is an LPG gas leak or if there is a fire or not. ESP32 functions as a processor to control the entire system that has been designed. The output of the designed system includes a fan and an alarm. The fan functions to release LPG gas if there is a gas leak and the alarm sounds so that the apartment security officer or apartment owner knows early.

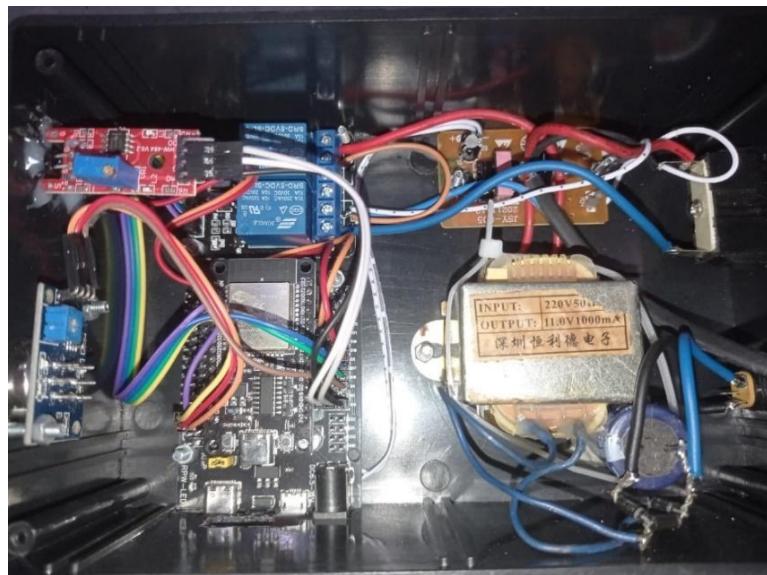


Figure 10. Implementation of the display on the Virtuino dashboard

c. Implementation of Virtuino dashboard

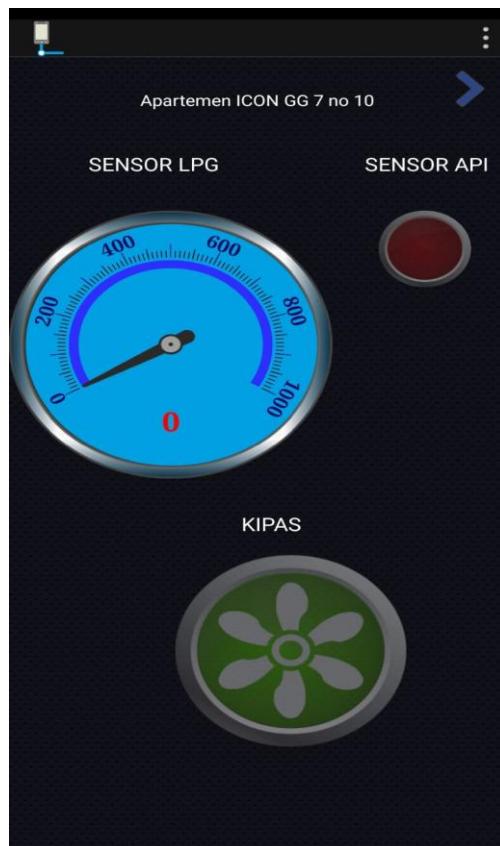


Figure 11. Virtuino display implementation

Figure 11 shows the appearance of Virtuino as an information provider and early warning to apartment officers and apartment owners / tenants. This system is expected to facilitate coordination in dealing with LPG gas leaks efficiently and systematically. Without reducing the privacy of apartment owners / tenants, the LPG gas monitoring system and monitoring the presence of fire or not can be easily carried out by apartment security officers.

5. Testing and Evaluation

After the system implementation is complete, a series of tests are conducted to validate the system's performance. Testing includes aspects of functionality, security, and performance. In addition, an evaluation is carried out on the impact of the system on operational efficiency, sensor data accuracy and connectivity of tools made with Virtuino.

6. Analysis and Reporting

The final stage is to analyze the results of testing and evaluating the system that has been created, and to compile a research report that includes findings, discussions, and recommendations for further research and development.

RESULTS AND DISCUSSION

After the implementation of each part of the tool that has been made, the next stage is testing the results of the entire system that has been designed. The results of the entire system that has been designed are as follows:

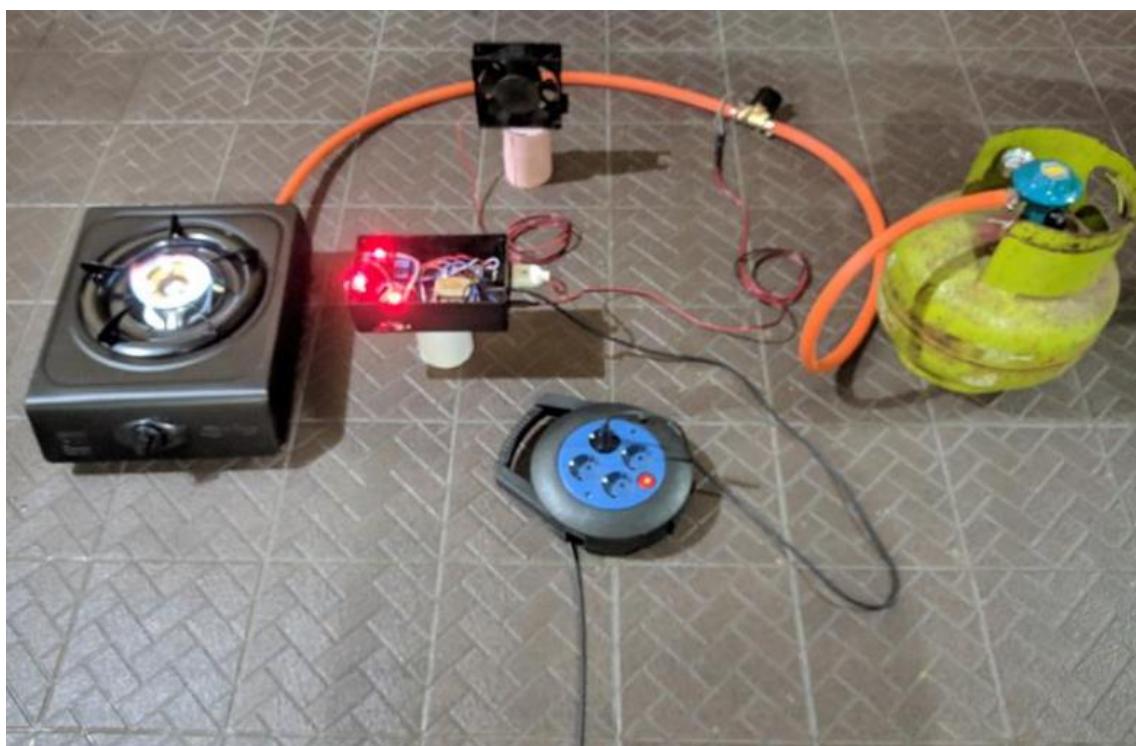


Figure 12. Results of the entire system that has been created

Figure 12 shows the overall results of the system that has been created in this study. In testing the overall system by approaching the system that will be placed in the kitchen. By giving different responses to the MQ 2 sensor, and the fire sensor, then the changes that occur on the Virtuino dashboard are seen. Changes in sensor values measured on the Virtuino dashboard are an indication of changes in the sensor values being tested. Wifi signal connectivity is an important parameter for the speed of data communication between the ESP32 and Virtuino.

The virtuino dashboard display as shown in Figure 11 can be accessed by the apartment security officer or the apartment owner. The virtuino dashboard display has address information from the monitored system, making it easier to detect if there are signs of gas leaks or fires in the apartment.

Rule Testing on System

Table 1. Rule testing on the system created

LPG (ppm)	Sensor Api	Keterangan
200	Not detected	Fan and Alarm Off
120	Not detected	Fan and Alarm Off
350	Not detected	Fan and Alarm On
300	Detected	Fan and Alarm On
360	Detected	Fan and Alarm On
100	Not detected	Fan and Alarm Off

Table 1 shows various rules with block testing of the system. To test whether an increase in LPG gas levels exceeding the threshold of 200 ppm will turn on the fan and alarm or not. It turns out that the test found that the rule works properly. LPG gas testing is done by bringing LPG gas close to the MQ 2 sensor. The fire sensor is tested by giving fire near the sensor, if there is fire then the system output will turn on the alarm and blower fan. The rule of this system will work by sending a fire warning message via Virtuino if one of the conditions is met such as if the LPG gas level exceeds 200 ppm or if the fire sensor detects fire. Based on all these tests, it is concluded that the system rule created is in accordance with the expected output.

CONCLUSION

Based on the results of the analysis and testing that has been done, it can be concluded that this study produces an innovative solution to prevent fires caused by LPG gas leaks and increase the effectiveness of handling if a fire occurs in an apartment. By utilizing technology in the development of an IoT-based LPG gas leak monitoring system using the ESP32 microcontroller, MQ 2 sensor, fire sensor, and Virtuino platform, it has been successfully developed and from the test results it functions well. The system can work according to the rules/regulations set, the Virtuino platform can display data from the ESP 32 microcontroller processing and provide messages via Virtuino following the specified rules.

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