IMPLEMENTATION OF IOT IN THE RADIATOR COOLANT CONTROL AND MONITORING PROTOTYPE ON GENSET USING ESP 32 BASED NODEMCU SMARTPHONES

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ABSTRACT

Generator sets (gensets) are important equipment for providing electricity during blackouts, ensuring activities that require an electricity supply to continue to run. One of the important components in a generator is the radiator, which functions to keep the engine cool and prevent overheating. Overheating can cause serious damage to generator engine components. Therefore, monitoring and controlling radiator coolant is very important. This research proposes a control and monitoring system for coolant radiators on generators using Internet of Things (IoT) technology with NodeMCU ESP32 which can be accessed via smartphone. This system is designed to detect the temperature and water level in the radiator in real-time. Data from the DS18B20 water temperature sensor and water level sensor will be sent to the server and can be accessed by users via a web-based application.

***Keywords**: Generator set, Radiator Coolant, IoT, NodeMCU ESP32, water monitoring, water control, Smartphone*

1. INTRODUCTION

A generator set is equipment that supplies electrical power during a blackout which is very useful for preventing all daily activities that require an electricity supply so that it can operate and not be delayed due to a power outage. In the generator engine itself, a coolant such as a radiator is definitely needed to keep it cool. Because of this, the radiator is an important part of a generator that cannot be separated from an engine. Only part of the energy in the fuel is given directly to the generator engine and later converted into mechanical power, while the rest can make the engine hot. This remaining heat will later be absorbed by the cooling material. The cooling material is available on the side or wall of the tube in the cylinder which forms the combustion chamber in the generator set engine. Basically, water cannot directly cool the engine.

In a power plant using diesel, what must be paid attention to is engine monitoring and maintenance. The normal temperature in the generator environment is 40 degrees Celsius and should not exceed 50 degrees Celsius. If the generator emits excessive heat, it will issue a high temperature warning and the generator will automatically stop working. The normal temperature of cooling water in a generator is between 700C and 850C. The highest temperature cannot exceed 900C. If the temperature is excessive, overheating will occur (Arthur Teknik, 2023).

Overheating namely a condition when the generator set engine temperature rises above normal. Overheating can cause engine components to wear out more quickly or even cause permanent damage to vital parts. To ensure the generator set engine does not overheat.

A cooling system called a radiator is needed to keep the generator engine temperature stable, so that engine performance can remain optimal. The radiator functions to remove heat from the vehicle engine, thereby preventing overheating and keeping the engine temperature stable. Combustion in a vehicle engine causes the engine to heat up, and this temperature will continue to increase as long as the generator set is in use. As a result, the temperature of the generator set engine will also continue to increase. Therefore, this component is very important as a cooling system to keep the engine temperature stable. The working principle of a radiator relies on a liquid called coolant or radiator water to keep the engine temperature stable, by transferring heat from the engine to the outside air. Therefore, it is very important to check the radiator water regularly.

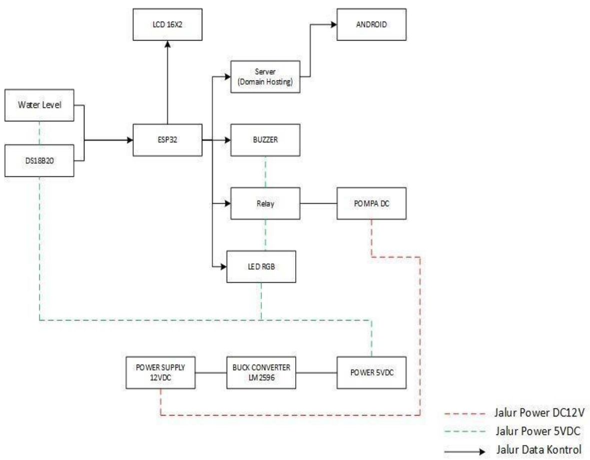
2. LITERATURE REVIEW

Generator A generator set is a device designed to generate electricity using an internal combustion engine, such as a gasoline or diesel engine, connected to an electric generator. This generator is usually used when the main electricity source is not available, such as in emergency situations, in remote locations, or in areas that are not connected to the public electricity grid. A generator set is a combination of two different devices: an engine and a generator or alternator. The engine is usually a diesel engine that uses diesel or gasoline to rotate the generator, while the generator or alternator consists of a copper coil with stator (static coil) and rotor (rotating coil) components to produce electricity.

A radiator is a tool designed to manage the temperature of a system. This component works by absorbing heat from hotter parts (for example the engine) and releasing it to a cooler environment. Radiators are generally found in motor vehicles and industrial machines that require optimal cooling.

The Internet of Things (IoT) concept is a concept that connects various physical devices to each other which are equipped with sensors and internet connectivity, so that they can operate automatically and independently. IoT is often equated with M2M (Machine-to-Machine), but in fact the two are different in scale and scope of use. M2M refers to technology that allows communication between machines automatically without involving humans, allowing machine systems to run certain programs independently.

3. METHODOLOGY



Based on the completed tool design block diagram, it can be seen that the 12VDC power supply will send power to the pump. The power obtained from other components is generated from reducing the 12VDC power to 5VDC by the Buck Converter LM2596 and there are two sensors that will be used as the basis for data collection, namely water level and temperature, where the water level is read by the JSN-SR04T sensor to determine the level of the radiator fluid. and the radiator fluid temperature is read by the DS18B20 sensor.

In the next process, ESP 32 acts as a microcontroller which functions as a data processing center from sensors to actuators to control and monitor the radiator water level, then the LCD installed on the sensor displays control and sensor parameters locally.

When the temperature exceeds the maximum limit or the height is below the minimum limit, the buzzer will sound when the water level is below the minimum limit, the relay will work as an automatic switch to activate the pump, and the pump which is powered by 12VDC will work if the water level is below the minimum limit.

The indicator process shows the temperature and water level conditions of the radiator when the safe condition is the led will be green, the led will be yellow in the alert condition, and the led will be red in the dangerous condition. In the data input process, there is a server and domain as a storage place for an online database which will read the conditions that actually occur in real life, which can be monitored online via smartphone, so that information about the condition of water temperature and water level can be monitored by the user in real time. Information is also displayed on the lcd installed on the esp 32, then the information system and manual control of this tool can be displayed on the android studio application which can be accessed by smartphone.

4. RESULT AND DISCUSSION

4.1 System Device Testing

This test aims to evaluate the performance of the tool, whether it is functioning optimally or whether there are still deficiencies. It is hoped that this tool can operate properly according to its function. The hardware used in this research includes a coolant radiator, generator set, and NODEMCU ESP 32, as well as other components that support this prototype. Meanwhile, the software used includes Android Studio, servers and domains which function to run and control access to the software. Apart from that, current developments in technology and communication cannot be separated from the role of the Internet of Things (IoT).

4.1.1 Radiator Testing

Figure 1. Radiator Coolant Testing

This test on the Coolant Radiator is carried out to determine that the radiator has been designed according to what is desired and works according to its function.

Table 1. Radiator Coolant Testing Data

Condition	Information
On	Water can come out normally

The measurement data shows that the radiator coolant is functioning properly.

4.1.2 ESP 32 Testing

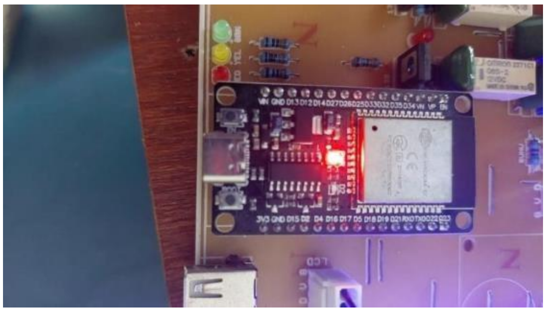


Figure 2. ESP 32 Testing

Testing on the ESP 32 Module is carried out to determine that all programs have been set according to what is desired and all sensors have been integrated according to their respective functions.

Table 1. ESP 32 Testing Data

Condition	Information
On	Normal

4.1.3 Testing Data Display to LCD

This testing stage needs to be carried out to ensure that the data obtained from the sensor and transmitted to the ESP 32 can be integrated with the LCD screen according to the conditions that occur in real time.

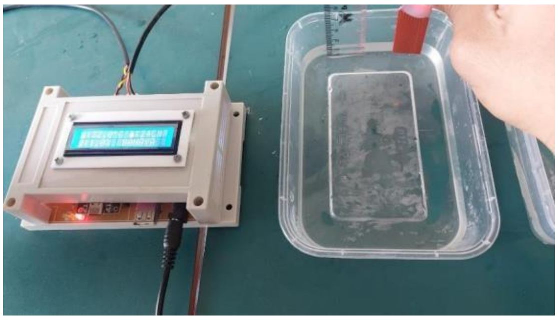


Figure 3. Test Data Test on LCD

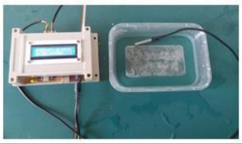
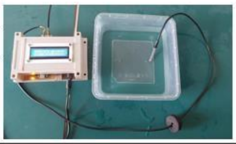
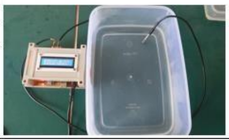
Table 3. INA219 Testing Data

Condition	Information
On	Normal

4.1.4 DS18B2 Temperature Sensor Testing

The temperature monitoring system is a system formed from a combination of several electronic components which are used to monitor the temperature produced by data collection by Esp 32 which is then displayed on the LCD and the history of the data will be stored and will be displayed via Android Studio which can be displayed by a smartphone.

Table 4. Temperature Sensor Test Data

Test	Time Lapse	Temperature	Documentation
Cold water	0	29^{o}	
	5 minutes	28^{o}	
	10 minutes	27^{o}	
Warm water	0	41^{o}	
	5 minutes	38^{o}	
	10 minutes	34^{o}	
Hot water	0	56^{o}	
	5 minutes	54^{o}	
	10 minutes	50^{o}	

4.1.5 Water Level Sensor Testing

The water level monitoring system is a system formed from a combination of several electronic components used for water levels produced by data collection by Esp 32 which is then displayed on the LCD and the history of the data will be saved and will be displayed via Android Studio which can be displayed by a smartphone.

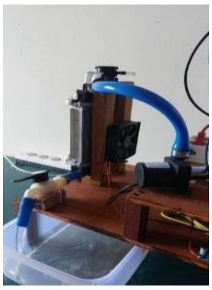
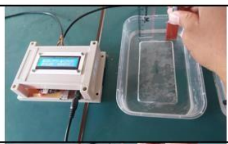
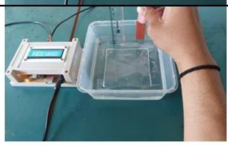
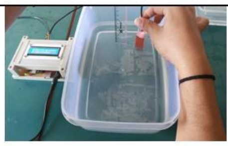


Figure 4. Water Level Sensor Testing

Table 2. Water Level Sensor Test Data

Test	LCD display Read	Documentation
Water aheight 50 mm	Dangerous Conditions	
Water height 100 mm	Alert Condition	
Water height 200 mm	Safe Conditions	

4.1.6 Buck Converter Testing

Figure 5. Buck Converter Testing

In practice, testing the buck converter will be used to reduce the voltage of the water pump so that the output from the pump is not too large.

Table 3. Buck Converter Testing

Condition	Information
On	Normal

4.1.7 Water Pump Testing

Figure 4.2 Water Pump Testing

In practice, water pump testing will later be used as a water scanner or water distribution.

Table 7. Water Pump Display

Condition	Information
On	Normal

4.1.8 Testing Android Application

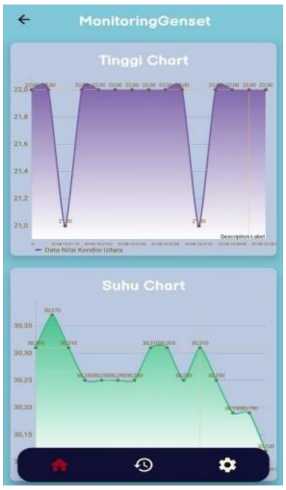


Figure 3. Android Application IoT Testing

To test monitoring from a smartphone, the first step is to ensure that the hardware that will be used to send data to the generator monitoring application is connected and functioning properly. This device is a sensor or microcontroller connected to the internet. Next, create an account in Android studio and create a new channel that will be used to store data. Each channel has a unique API key, which needs to be stored and used in the device code to send data. Then, write and upload the appropriate code to the hardware, ensuring that the code contains the correct API key and endpoint for the generator monitoring application.

After that, run the device and to test monitoring from the smartphone, the first step is to ensure that the hardware that will be used to send data to the generator monitoring application is connected and functioning properly.

This device is usually a sensor or microcontroller connected to the internet. Next, create an account in Android studio and create a new channel that will be used to store data. Each channel has a unique API key, which needs to be stored and used in the device code to send data. Then, write and upload the appropriate code to the hardware, ensuring that it contains the correct API key and endpoint for the generator monitoring application. After that, run the device and monitor data delivery in real-time on the application dashboard. Check that the data appears correctly in the dashboard that has been created. If the data does not appear, check the hardware connection, code and configuration of the generator monitoring application again. Monitoring is considered successful if data from the hardware appears correctly and consistently on the application dashboard according to the predetermined delivery interval.

4.2 Overall System Testing

Figure 7. Overall System

Testing the Arduino program is very important to ensure that no errors will occur when the program is connected to the hardware or prototype that has been created. This process involves checking and analyzing code that has been written using the programming language attached to the document. In this testing stage, all the code that has been designed is entered into the Arduino system, then a detailed analysis is carried out to detect any mistakes or errors in the code.

If the code can run but the device or prototype does not operate according to the commands written by the programmer, this indicates that there is an error in the code. Therefore, it is necessary to check and revise the code until the device can function as expected. Apart from testing the code, testing the hardware is an important step that should not be ignored.

The first step in hardware testing is to check that each component can function normally. This test aims to ensure that the performance of each component is as designed and required by the device. This is very crucial because one component that is not suitable can cause the device to not function properly, or even be damaged.

4.3 Analysis

Monitoring carried out by the monitoring application runs well, allows real-time data monitoring and makes it easy to monitor various parameters continuously. In the program that has been created, the time to send data to the monitoring application is set every 5 seconds, so that data will be sent every 5 seconds. This data delivery time is very flexible and can be adjusted according to user needs, because it allows the use of applications so that the database does not pile up and can run smoothly and allows adjustment of delivery intervals to suit various monitoring needs.

However, keep in mind that the faster the data transmission interval, the greater the need for a stable and fast internet connection to ensure data can be sent without interruption or loss. A slow or unstable connection can cause delays or even failure in data transmission, which can affect the accuracy and reliability of the monitoring carried out. Therefore, it is important to consider the capacity and quality of the internet connection when determining the data transmission interval for the monitoring application. With the right settings and adequate connections, monitoring applications can be a very effective tool in monitoring various parameters in real-time, providing accurate and relevant data for analysis and decision making.

Monitor data delivery in real-time on the application dashboard. Check that the data appears correctly in the dashboard that has been created. If the data does not appear, check the hardware connection, code and configuration of the generator monitoring application again. Monitoring is considered successful if data from the hardware appears correctly and consistently on the application dashboard according to the predetermined delivery interval.

At the analysis stage in making an IoT implementation on a prototype for controlling and monitoring radiator coolant on a generator using a smartphone-based NodeMCU ESP32, the author has carried out an in-depth analysis and collected data and information from various relevant previous research studies. Through a comprehensive study of the differences and shortcomings in previous studies, the authors were able to identify areas that require improvement and innovation. Based on these findings, the author then carried out development and refinement of the components and design of the tools to be designed, with the aim of increasing the efficiency, reliability and functionality of the control and monitoring system. The results of this analysis stage are an important basis for developing more advanced innovations that are in line with the needs of implementing IoT on generator coolant radiator prototypes.

4.4 Implementation

4.4.1 Implementation in Industry

1. Remote Monitoring
   a. Description: By using NodeMCU ESP32, the condition of the generator coolant radiator can be monitored in real-time via smartphone. This allows operators to know the condition of the generator without having to be at the physical location.
   b. Benefits: Increase operational efficiency and reduce maintenance costs by detecting problems early.
2. Control Automation
   a. Description: This tool can be configured to automatically control coolant temperature,

turning on or off the generator based on predetermined parameters.

b. Benefits: Reduces the risk of overheating and engine damage, and optimizes generator performance.

3. Data Collection and Analysis

a. Benefits: Reduces the risk of overheating and engine damage, and optimizes generator performance.

b. Benefits: Extends generator life and reduces downtime.

4. Integration with Factory Management System

a. Description: This tool can be integrated with existing factory management systems to provide a holistic view of factory operations.

b. Benefits: Improves coordination and responsiveness to operational conditions.

4.4.2 Implementation at the Airport

1. Generator Monitoring at Critical Facilities

a. Description: Airports have many critical facilities such as runway lights, control towers and navigation systems that depend on a stable power supply. Implementing IoT on generators can ensure reliable power supply.

b. Benefits: Ensures safe and uninterrupted airport operations.

2. Quick Response to System Failures

a. Description: With real-time notifications sent to smartphones, airport technicians can respond more quickly to generator system failures.

b. Benefits: Long-term cost savings and more efficient resource allocation.

3. Operational Cost Savings

a. Description: Control and monitoring automation reduces the need for routine manual checks, thereby saving operational costs.

b. Benefits: Long-term cost savings and more efficient resource allocation

4. Compatibility with Airport Security and Management Systems

a. Description: This tool can be integrated with airport security and management systems to provide an additional layer of surveillance.

b. Benefits: Improves airport operational security and order.

4.5 Evaluation

The final step is to evaluate the implemented system. In this phase, an evaluation is carried out to ensure that the objectives of designing this tool meet the requirements to become part of airport operational equipment. This control and monitoring is very important for flexibility and control and monitoring of airport generator set radiators so that they are easier to monitor and maintain over long distances. Then the author will do it to find out what needs to be added and improved so that this tool can fully become a tool that can be used.

5. CLOSING

5.1 Conclusions

From all research trials, it can be concluded as follows:

1. Making a prototype for control and monitoring of radiator coolant on generators using a smartphone-based nodemcu esp 32 is to ensure continuous and efficient water supply, as well as increasing the operational reliability and safety of generators at airports. This system will monitor and regulate the radiator water supply in real time, adaptive to workload, and detect potential radiator leakage damage, so that critical equipment continues to function optimally during power outages or emergency situations.
2. The test system that has been created has been successfully used to optimize the output data so that it is close to the original data that has not been trained, with a difference that is not too large. The quality of the output data depends on the amount of data trained, where more training results in smaller differences and more optimal values.

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