LAPORAN KERJA PRAKTEK
INTERNATIONAL COURSE PROGRAM (ICP) REPORT
DESIGN OF AN INTERNET OF THINGS-BASED SMART AC CONTROLLER SYSTEM TO SUPPORT ENERGY EFFICIENCY IN BUILDINGS

Compiled By:

Namira Putri 238150034

PROGRAM STUDI TEKNIK INDUSTRI

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LEMBAR PENGESAHAN

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ABSTRACT

The increase in electrical energy consumption in buildings, particularly due to the use of Air Conditioners (AC), demands a more efficient and sustainable control system. One solution that can be established is the use of Internet of Things (IoT) technology to optimize the control of air conditioning systems. This study aims to design an IoT-based Smart AC Controller system that is capable of automatically controlling AC operation based on environmental conditions and user preferences. The methods used include system requirements analysis, system architecture design, and AC control process flow modeling. The system is designed by integrating temperature and humidity sensors, control units, gateways, database servers, user dashboards, and external data sources in the form of weather forecasts. Environmental data obtained from sensors is processed by the control unit to produce AC control decisions which are then implemented through actuators in the HVAC system. The design results show that the IoT-based Smart AC Controller system is capable of supporting more adaptive, structured, and data-driven AC control. This system has the potential to increase the efficiency of electrical energy use without reducing the comfort of room users.

Keywords: Smart AC Controller, Internet of Things, Energy Efficiency

FOREWORD

All praise and gratitude the author prays to the presence of God Almighty, thanks to the abundance of His Grace and love the author can complete the International Course Program report as a substitute for the Internship Report entitled "Design of an Internet of Things-Based Smart AC Controller System to Support Energy Efficiency in Buildings". The writing of this internship report is one of the requirements for students to complete their studies at the Faculty of Industrial Engineering, Medan Area University. In preparing this internship report, the author has received a lot of help and guidance from various parties, so on this occasion the author would like to express his deepest gratitude to:

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The author welcomes constructive criticism and suggestions for the perfection of this internship report. He hopes this internship report will be useful to both the author and any readers who need it.

Medan, February 11, 2026

Namira Putri

LIST OF CONTENS

LIST OF FIGURES

CHAPTER I
INTRODUCTION

1.1 Background

Buildings are one of the sectors with a relatively high level of energy consumption, especially in air conditioning systems or Air Conditioner (AC). Continuous use of air conditioning with inappropriate settings can lead to a significant increase in electricity consumption. This condition not only increases building operating costs but also contributes to increased carbon emissions, which negatively impact the environment. In practice, many buildings still use conventional AC systems that are manually operated without considering actual room conditions, such as changes in temperature, humidity levels, number of occupants, or time of use, thus potentially causing energy waste.

In perspective Green Engineering Energy efficiency is one of the main principles that must be applied in the design and management of building systems. Green Engineering emphasizes efforts to optimize resource use, reduce energy waste, and minimize environmental impact without compromising function and comfort for users. The application of this concept in building systems encourages the need for a more systematic and integrated approach, especially in energy management in supporting facilities such as air conditioning systems. One relevant approach is the use of automation technology that can adjust system performance based on actual conditions (Zimmerman, 2003).

Technological development The Internet of Things (IoT) offers significant opportunities to support the implementation of automation systems in buildings. IoT enables various devices and sensors to connect and exchange data in real time over the internet. By leveraging this technology, air conditioning control systems can be designed to be more intelligent, adaptive, and responsive to changing room conditions. Data obtained from sensors can be used as a basis for decision-making in automatically regulating air conditioning performance, thus optimizing energy use.

Based on these problems, a system design is required. Smart AC Controller an Internet of Things-based system that integrates automation concepts and Green Engineering principles. The designed system is expected to be a conceptual solution to support energy efficiency in buildings through more structured and adaptive air conditioning control, while maintaining room comfort for users.

1.2 Formulation of the problem

Based on this background, the formulation of the problems discussed are:

1. How to design an Internet of Things-based Smart AC Controller system in a building?
2. How is the system workflow based on input, process and output processes?
3. How can the design of such a system support efficiency for the building?

1.3 Objective

The purpose of making a report based on the problem formulation is:

1. Designing a Smart AC Controller system based on the Internet of Things (IoT).
2. Explaining the working mechanism of the system through the concepts of input, process, and output.
3. Examining the role of systems in supporting energy efficiency in buildings.

1.4 Benefit

The expected benefits of preparing this report are:

1. Provides an overview of the design of an IoT-based Smart AC Controller system.
2. Supporting the implementation of Green Engineering concepts in buildings.
3. To be a reference for researchers or developers of similar systems in the future.

CHAPTER II
LITERATURE REVIEW

2.1 Internet of Things (IoT)

The Internet of Things (IoT) is a technological concept that enables various physical devices to connect, communicate, and exchange data over the internet without direct human interaction. These devices are generally equipped with sensors, actuators, and data processing systems that enable automated decision-making. IoT plays a crucial role in supporting adaptive, real-time systems, particularly in energy management and building automation (Gubbi, Buyya and Marusic, 2012).

IoT architecture generally consists of three main layers: the perception layer, the network layer, and the application layer. The perception layer collects data from the environment through sensors, such as temperature and humidity. The network layer is responsible for sending data to a server or cloud platform via a communication network. Meanwhile, the application layer is used for data processing, information visualization, and remote system control. In the context of air conditioning control in buildings, IoT enables the system to continuously monitor room conditions and adjust AC performance based on actual data. Thus, IoT can support energy efficiency through more accurate and integrated control.

2.2 System Smart Building

A smart building is a building concept that integrates information and communication technology with automation systems to manage various facilities efficiently and coordinated. This system includes lighting, security, ventilation, and air conditioning. Smart buildings are designed to improve operational efficiency, occupant comfort, and environmental sustainability.

One of the key characteristics of a smart building is its ability to collect and analyze data from various building systems. This data is used to optimize the use of energy and other resources. A smart building can be viewed as an integrated system aimed at improving the efficiency and effectiveness of overall building performance. The implementation of smart buildings is closely related to the concept of Green Engineering, as it can reduce energy waste and support sustainable building management. The Smart AC Controller system is a crucial component in a smart building because the air conditioning system contributes a significant portion of energy consumption.

2.3 Air Conditioning (AC) System

An air conditioner (AC) is a device that functions to regulate the temperature, humidity, and air quality in a room to create comfortable conditions for the user. The AC system works by transferring heat from the room to the outside environment through a refrigeration cycle. Uncontrolled use of AC can cause a significant increase in electrical energy consumption. Factors that affect AC energy consumption include the duration of use, temperature settings, AC capacity, and environmental conditions such as outdoor temperature and occupancy levels. In conventional systems, AC operation often does not dynamically consider these factors, resulting in energy inefficiency. Therefore, a smarter and more adaptive control system is needed so that AC performance can be adjusted to actual room conditions. The integration of AC systems with IoT technology enables automatic control that has the potential to reduce energy waste (Pe, 2008).

2.4 Energy Efficiency from a Green Engineering Perspective

Energy efficiency is an effort to utilize energy optimally to produce maximum system performance with minimal energy consumption. In the context of Green Engineering, energy efficiency is a key principle that aims to reduce the use of natural resources and minimize the environmental impact of human activities. Green Engineering emphasizes a preventive approach in system design, namely by considering environmental aspects from the initial design stage (Mayfield, Beck and Mayfield, 2014). In buildings, energy efficiency can be achieved through energy automation technology, appropriate system selection, and integrated energy processing. Intelligent air conditioning control is one effective strategy because air conditioning systems have a significant contribution to building energy consumption.

By implementing an IoT-based Smart AC Controller system, energy efficiency can be supported through more controlled and appropriate AC usage settings, thus aligning with the principles of Green Engineering.

2.5 Input-Process-Output System Concept

The Input-Process-Output concept is a systems approach used to describe the workflow of a system in a structured manner. Input is data or resources entering the system, process is the input processing stage, while output is the results produced by the system. This concept is widely used in system analysis and design, especially in the engineering field. In designing a Smart AC Controller system, the IPO concept is used to systematically explain the system's working mechanism. Input in the form of temperature, humidity, and usage time data is processed by the control system to produce output in the form of AC work settings. The IPO approach facilitates the analysis of relationships between system components and helps in designing an efficient and integrated system.

The use of IPO also supports system evaluation from an energy efficiency perspective, as each stage can be analyzed for its contribution to performance and energy use.

CHAPTER III
METHODOLOGY

3.1 Research methods

The research method applied in this report is a system design method. This approach is oriented towards a series of systematic activities to design, develop, and evaluate a system or model to provide solutions to identified problems (Esearch *et al.*, 2004). This method is not intended to test hypotheses through quantitative data analysis, but rather aims to produce a system design that is logical, structured, and in accordance with the needs that have been analyzed. In its implementation, the system design method is implemented to design an Internet of Things-based Smart AC Controller system that aims to improve energy efficiency in buildings. This approach is in accordance with the needs of analysis and synthesis in complex system design. Philosophically, the research steps also support the application of environmentally responsible design principles, by integrating sustainable aspects into the engineering process from the early stages of development.

3.2 Research Stages

The research stages are systematically structured to ensure the design process is structured and directed. The research stages are as follows:

1. **Literature Study**

   This stage is carried out by studying various library sources related to the Internet of Things, smart building systems, AC control, efficiency energy, and Green Engineering. The literature study aims to obtain a theoretical basis and relevant conceptual references as a basis for system design.

2. **System Requirements Analysis**

   At this stage, system requirements are identified based on existing problems. The requirements analysis includes the functional and non-functional requirements that the Smart AC Controller system must meet to support energy efficiency.

3. **Smart AC Controller System Design**

   The design phase includes developing the system architecture, designing inputs, processes, and outputs, and the overall system workflow. The design is carried out with the principles of system efficiency and automation in mind.

4. **Evaluation Planning Conceptually**

   The evaluation was conducted to assess the suitability of the system design to the research objectives and Green Engineering principles. This evaluation was conceptual in nature that is through analysis of system logic and its relationship to energy efficiency, without conducting direct testing in the field.

3.3 System Requirements Analysis

The system requirements analysis aims to determine the system specifications required for the Smart AC Controller system to function optimally. System requirements are divided into two categories, namely functional requirements and non-functional requirements (C.Laudon and Laudon, 2022). Functional requirements include the system's ability to read room environmental conditions such as temperature and humidity. The system must also be able to make decisions based on data obtained in the designed control logic. Non-functional requirements include aspects of system reliability, ease of use and energy efficiency. The system is expected to be able to work stably and consistently in supporting building energy management. From a Green Engineering perspective, these non-functional requirements are important because they are directly related to the goals of sustainability and resource optimization.

3.4 Smart AC Controller System Design

The Smart AC Controller system design was conducted using the Input–Process–Output (IPO) approach to clearly and structured describe the system workflow. This approach facilitates the analysis of the relationships between system components and supports efficient and integrated system design.

3.4.1 System Input Planning

System input is data used as the basis for decision-making in AC control. The main inputs in this system include room temperature, air humidity, and usage time obtained through sensors and a scheduling system. Temperature and humidity data are used to describe the actual condition of the room, while time data is used to regulate AC operation based on certain usage patterns. The use of accurate and relevant inputs allows the system to adjust AC performance to real conditions, thereby reducing unnecessary energy use. This is in line with the principles of efficiency and eco-friendliness (Gubbi, Buyya and Marusic, 2012).

3.4.2 System Process Planning

The system process is the stage of input data processing carried out by the microcontroller or main control unit. At this stage, data obtained from the sensors is analyzed and compared to predetermined parameters or thresholds. Based on the analysis, the system makes decisions to automatically control the AC operation.

The control logic is designed to ensure the air conditioner operates only as needed in the room, thus preventing overcooling. This automation process is key to supporting energy efficiency, as it reduces reliance on manual operations that tend to be suboptimal.

3.4.3 System Output Planning

The system output is the final result of the data processing performed by the Smart AC Controller system. The main output is AC control commands, such as turning the AC on or off and automatically adjusting the temperature. Furthermore, the system also generates information on the AC status and room conditions, which can be displayed via an IoT platform for monitoring. This output is expected to ensure the AC operates optimally according to the room's needs. With structured and automated control, the system is able to support energy efficiency and improve user comfort without excessively increasing energy consumption.

3.5 Tools and Devices Used

3.5.1 Hardware

a. Temperature and Humidity Sensor

Used to obtain environmental condition data as system input. Here are some examples of commonly used sensors:

1) The DHT11, a temperature and humidity sensor with basic accuracy, is often used for prototyping.
2) DHT22 (AM2302), has a wider measurement range (-40 to 80°C) and better accuracy (±0.5°C) than DHT11.
3) SHT31 / SHT21, sensors with very high accuracy (SHT31 reaches ±0.2°C) and uses the I2C communication protocol.
4) The LM35 is a very popular analog sensor due to its linearity, where every 1°C increase in temperature produces a 10mV output. Its precision is quite good (±0.5°C at room temperature), but it is susceptible to interference noise on a long cable.

b. Microcontroller

Functioning as a data processing and decision-making center. Here are some commonly used types of microcontrollers:

1) Arduino Uno, used for IoT system prototype.
2) ESP8266, a microcontroller with an integrated Wi-Fi module.
3) ESP32, supports Wi-Fi and Bluetooth with higher performance.
4) Raspberry Pi, used for higher data processing.

c. Communication Module

Used to connect the system to the internet network. Several types of communication modules:

1) Wi-Fi Module (ESP8266, ESP32), commonly used in in-building IoT systems.
2) Ethernet Module (ENC28J60), used in wired networks.

d. Actuator (Controller)

Used to execute system commands on AC devices.

1) Relay module, an electronic switch that can be controlled using a low voltage electrical signal (e.g. 3.3V/5V from a microcontroller such as Arduino or ESP32) to disconnect or connect a high voltage electrical current (220V AC).
2) The IR Transmitter Module is an infrared transmitter that can send data to the IR receiver on the indoor AC unit. This module is used to mimic the signal sent by the original AC remote.
3) A Smart AC Controller Module is an all-in-one device specifically designed to control smart ACs. This module typically integrates an IR transmitter, temperature and humidity sensors, Wi-Fi/Bluetooth, and firmware.

3.5.2 Software

a. Microcontroller Programming Software

Works for writing, compile, and upload the program code to the microcontroller hardware (ESP32, Arduino, Raspberry Pi) to run the control logic.

1) Arduino IDE, uses C/C++ with extensive libraries. Suitable for Arduino, ESP8266, and ESP32 boards. Lightweight and easy to use, but has limited debugging features.
2) Platform IO, an extension for Visual Studio Code, supports multiple platforms (Arduino, ESP-IDF, STM32, etc.). Key features include automatic library management, IntelliSense, debugging, and unit testing. Highly recommended for large-scale projects.

b. Platform IoT

1) Blynk, a popular platform for building control applications with a drag-and-drop interface. Version 2.0 supports various connectivity options (Wi-Fi, BLE, Ethernet). It's very fast for creating mobile dashboards.
2) Firebase, Backend as a Service with Realtime Database, Firestore, Authentication, and Cloud Functions features. Commonly used with ESP32 via REST API or Firebase-ESP8266 library. Suitable for applications that require instant data synchronization between devices.

3) ThingSpeak, an open-source service from MathWorks. Focuses on simple data logging and analysis with MATLAB integration. Suitable for academic and software projects. prototyping.

c. Database Management System (DBMS)

Functions to store historical data such as temperature, humidity and AC status in a structured manner, both relational and non-relational.

1) MySQL, a powerful relational (SQL) DBMS. It's lightweight and widely used in conjunction with PHP/Node.js. PostgreSQL offers more advanced features like JSON support and concurrency high. Suitable for dashboard A website that requires historical reporting.
2) MongoDB, a document-based (JSON) NoSQL DBMS. Ideal for data with variable schemas, such as logs from various sensors. Often used in MEAN/MERN stack architectures.

d. Dashboard and Monitoring Software

A visual interface for users to monitor system conditions and send commands.

1) Web Dashboard, built with modern frameworks like React, Vue, or Angular. Data is fetched from API/REST or MQTT. It offers complete freedom in design and functionality.
2) Grafana, an open-source analytics and monitoring platform. It's specifically designed for visualizing time-series data from various sources (InfluxDB, Prometheus, MySQL, etc.). It offers highly professional and embeddable graphical interfaces.
3) Node-RED Dashboard is a flow-based programming tool that provides ready-to-use dashboard modules. Drag-and-drop charts, buttons, and indicators can be created. It's quick for prototyping.

3.6 Flow diagram

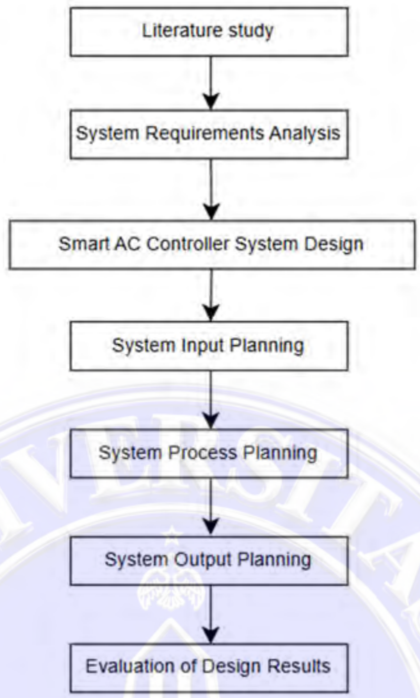

Figure 1. Flowchart

CHAPTER IV
RESULTS AND DISCUSSION

4.1 System Design Overview

The IoT-based Smart AC Controller system design was developed as a conceptual solution to improve energy efficiency in buildings through automatic control of air conditioning systems (Erkamim, 2023). This system is designed with an integrated approach that combines environmental sensors, data processing devices, and an IoT platform as a control monitoring medium. The sensors function to obtain data on actual room conditions, such as temperature and humidity. This data is then processed by a microcontroller that acts as the system's control center (Pressman, 2010). The IoT platform is used as an interface to display information on room conditions and the AC's operating status in real time. This integration between components allows the system to work adaptively to changing environmental conditions, so that AC operation is no longer static or dependent entirely on user intervention. This system can be viewed as a working system designed to optimize the use of energy resources through structured and information-based control. This approach is in line with the goals of operational efficiency and sustainable energy management.

4.2 System Input Discussion

System input is the initial element that determines the quality of decision-making in a Smart AC Controller system. The primary input, room temperature and humidity data, is used to represent actual environmental conditions. This information is crucial because thermal comfort and room cooling requirements are significantly influenced by these two parameters. With sensor-based input, the system is able to detect changes in room conditions in real time. This allows for more responsive AC control compared to conventional systems that rely solely on manual settings. From an energy efficiency perspective, the use of sensor input helps prevent AC operation when additional cooling is not actually needed, thereby reducing unnecessary energy consumption (Pe, 2008).

In addition, the input data obtained can be the basis for developing more sophisticated systems in the future, such as usage pattern-based control or integration with building energy management systems.

4.3 System Process Discussion

The system process is the core of the Smart AC Controller's working mechanism. At this stage, input data obtained from sensors is processed by the microcontroller to determine AC control actions (Martinez, 2023). The data processing process is carried out automatically based on pre-designed logic or rules, such as comparing room temperature with a predetermined threshold value. This automation of the control process reduces reliance on user intervention, which is often subjective and less than optimal in terms of energy efficiency. With a system that works automatically and consistently, AC operation can be adjusted to the actual needs of the room, so that AC operating time can be minimized without reducing comfort (Bolton, 2009).

This automation process reflects the principle of preventing energy waste through intelligent and adaptive system design. It also opens up opportunities for further development, such as the implementation of more complex control algorithms to improve system efficiency.

4.4 System Output Discussion

System output is the final result of data processing and decision-making within the Smart AC Controller system. The primary output is AC control commands, such as turning the AC on or off and automatically adjusting the temperature. Furthermore, the system also generates information about the AC's status and room conditions, which can be displayed via an IoT platform for monitoring.

The resulting output is designed to ensure that the AC operates according to the room's needs. With automatic control, the system can maintain room conditions within a thermal comfort range without overcooling. This directly contributes to reduced electricity consumption. In the context of a building management system, the Smart AC Controller system output can be part of a broader decision-making system, supporting integrated and sustainable building energy management.

4.5 System Plan

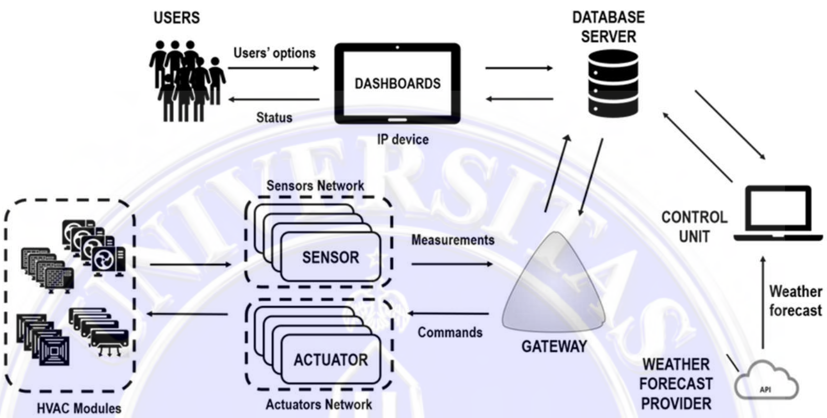

Figure 2. Smart AC Controller System Process

In the initial phase of the system, users interact with the Smart AC Controller system through a dashboard accessed using an IP-based device, such as a computer, tablet, or smartphone. The dashboard serves as a user interface that allows users to provide AC setting preferences, such as desired temperature, as well as monitor room conditions and system status in real-time. This two-way interaction provides flexibility to users without eliminating the system's automation functions. Thus, the system does not rely entirely on manual operation, but rather prioritizes data-driven control.

The dashboard is connected to a database server that serves as the system's central data storage and management center. This database stores historical data on room temperature and humidity, AC and HVAC system operational status, user preferences, and data processing results and system decisions. The database allows the system to record and process data in a structured manner, allowing it to be used for long-term system performance analysis. This historical data is crucial for identifying energy consumption patterns, evaluating system efficiency, and identifying opportunities for energy savings and future system design improvements.

The control unit is the core component of the Smart AC Controller system, responsible for data analysis and AC control decision-making. This unit receives data from a database server as well as supporting information from external sources, such as weather forecasts. Based on this data, the control unit analyzes room conditions and determines the most appropriate control actions, such as turning the AC on, off, or adjusting settings.

The Smart AC Controller system is also integrated with weather forecast provider Using an Application Programming Interface (API) to obtain weather forecast data. Information about external weather conditions, such as outdoor temperature, is used as supporting data in the AC control decision-making process. By considering weather forecast data, the system can be more proactive, for example, by adjusting cooling strategies before ambient temperatures increase. This weather data integration enhances the system's ability to anticipate energy needs, thus supporting energy efficiency and sustainable building management.

Gateways serve as a link between digital systems, such as servers and control units, and physical devices in the field. Gateways receive measurement data from a network of sensors and transmit control commands from the control unit to a network of actuators. The presence of gateways ensures reliable and structured communication between the digital and physical worlds. In IoT systems, gateways play a strategic role in maintaining data flow continuity, system reliability, and ensuring that control commands are implemented promptly on physical devices.

A sensor network consists of multiple sensors installed in a room or HVAC system to measure environmental parameters, such as temperature and humidity. These sensors operate continuously to obtain data on the actual room conditions, which are then transmitted to a gateway. The resulting data reflects the actual state of the building environment, thus serving as the primary basis for AC control decisions. With a sensor-based system, AC operation can be tailored to actual needs, preventing overcooling and supporting increased energy efficiency.

An actuator network consists of devices responsible for receiving and executing control commands from the system, such as an air conditioning control module. Commands sent through the gateway can include instructions to turn the air conditioning on, off, or adjust cooling capacity. With an actuator network, decisions made by the control unit can be directly implemented on the physical devices. This creates a responsive, automated, and consistent control system, supporting more efficient energy management.

The HVAC module is the final element in the Smart AC Controller system, where control decisions are realized in the form of air conditioning system operation. This module operates according to commands received from the actuator network, so that AC operation can be adjusted to room conditions and predetermined energy efficiency strategies. Integrated and automated HVAC control allows for reduced electricity consumption without sacrificing user comfort.

4.6 The Relation of the Plan to Green Engineering

The IoT-based Smart AC Controller system design strongly aligns with Green Engineering principles, particularly in terms of energy efficiency and environmental impact reduction. By optimizing AC control based on actual room conditions, this system contributes to reducing excessive electricity consumption.

Green Engineering emphasizes the importance of system design that considers environmental impacts from the outset. This system design reflects this approach by integrating automation and information technology as tools to achieve energy efficiency. Furthermore, this system supports the concept of building sustainability by minimizing energy waste without sacrificing user comfort. Overall, the Smart AC Controller system design can be seen as the first step in implementing smart building systems oriented towards sustainability and resource efficiency.

CHAPTER V
CLOSING

5.1 Conclusion

Based on the design and discussion results of the Smart AC Controller system based on the Internet of Things, it can be concluded that this system is designed as a conceptual solution to support energy efficiency in buildings, especially in controlling the use of Air Conditioners (AC). The system design integrates sensors, microcontrollers, IoT communication networks, and monitoring platforms so that AC operation can be carried out automatically and based on actual room conditions. The system design approach using the Input–Process–Output (IPO) concept shows that temperature and humidity data as the main input can be systematically processed by the control unit to produce more optimal AC control decisions. This automatic control process reduces dependence on manual operations that tend to be inefficient and have the potential to cause energy waste.

The system design also demonstrates a strong link to Green Engineering principles, particularly in efforts to optimize energy use and reduce environmental impact. By utilizing IoT technology, the system is able to support building energy management in a more structured, adaptive, and sustainable manner without compromising the comfort of room users. Furthermore, from an Industrial Engineering perspective, the Smart AC Controller system reflects the application of data-driven process control, system integration, and increased operational efficiency. This design can serve as a basis for the development and implementation of broader smart building systems in the future.

5.2 Suggestion

Based on the design results and discussions, several suggestions can be provided for further research development. Future research could implement the system directly in a real building to obtain quantitative data related to energy savings and increased system efficiency. This data can be used to measure system performance more objectively. System development can also be carried out by adding other input parameters, such as room occupancy levels or light intensity, so that AC control becomes more adaptive and comprehensive. Furthermore, integrating the Smart AC Controller system with the building energy management system could be a further step to support centralized energy management.

From a technological perspective, the system can be developed by implementing more sophisticated control algorithms, such as fuzzy logic or machine learning, to improve decision-making accuracy. Meanwhile, from a Green Engineering perspective, further research is expected to more thoroughly evaluate environmental impacts, including the potential for carbon emission reductions due to increased energy efficiency.

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ATTACHMENT