CYBER-PHYSICAL SYSTEM FINAL PROJECT REPORT
DEPARTMENT OF ELECTRICAL ENGINEERING
UNIVERSITAS INDONESIA

Automatic Room Cooler

GROUP 18

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PREFACE

In today's fast-paced world, demand for convenient home appliances has increased exponentially. Cooling systems, in particular, have a vital role in enhancing comfort in a tropical and humid country, while also helping optimize energy usage. This project aims to create cost-effective and energy-efficient cooling systems. Using skills that are taught in cyber-physical system class and laboratory.

Development for this product encompasses both hardware and software components. The hardware included fans, temperature sensor, control interface, and microcontroller. While the software is created to process the sensor's readings, register the control interface's readings, determine the fan behavior from sensor and control interface, and display the relevant reading.

This project imposed numerous challenges, for students, in hardware compatibility or the intricacies of low-level programming language. And each hurdle deepens our understanding of the cyber-physical system. This report documents the planning, implementation, testing, and evaluation of this product.

Finally, we would like to extend our gratitude to our fellow group member and project advisor. Whose guidance and cooperation are essential to completing the project. Additionally, we want to be thankful to our peers and family for their support and encouragement throughout this endeavor.

Depok, May 26, 2024

Group 18

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CHAPTER 1

INTRODUCTION

1.1 PROBLEM STATEMENT

Living in the modern world, indoor comfort are an essential luxury. Maintaining a comfortable temperature can help well-being, rest, comfort, and productivity. The main method of cooling systems is air conditioners which have a drawback of expensive operational cost, high energy consumption, and complex mechanisms. Not to mention the high amount of greenhouse gas emissions from operating air conditioners.

Hence, the primary problem, this project tries to address, is the weakness of common cooling systems. This project wishes to produce products that, energy-efficient, automated, cost-effective, and have low greenhouse gas emission.

1.2 PROPOSED SOLUTION

The proposed solution is an automated room cooling system. These systems utilize fan and ventilation as a method to circulate cool air and lower the temperatures. By only using these tools, emission of greenhouse gasses is limited. Usage of fans are also controlled by an Arduino microcontroller in conjunction with temperature sensors. Adjusting to the ambient temperature, fans speed can be controlled by the microcontroller. This optimization improves the system's energy-efficiency and cost-effectiveness.

1.3 ACCEPTANCE CRITERIA

The acceptance criteria of this project are as follows:

1. The system must be able to continuously monitor the room temperature with an accuracy within one degrees celsius.
2. The system must be able to activate and deactivate the fan.
3. The system must be able to adjust the fan speed based on the current room temperature.
4. The system must have a user interface for the desired temperature range.

5. The system must have a display interface for the desired temperature.

1.4 ROLES AND RESPONSIBILITIES

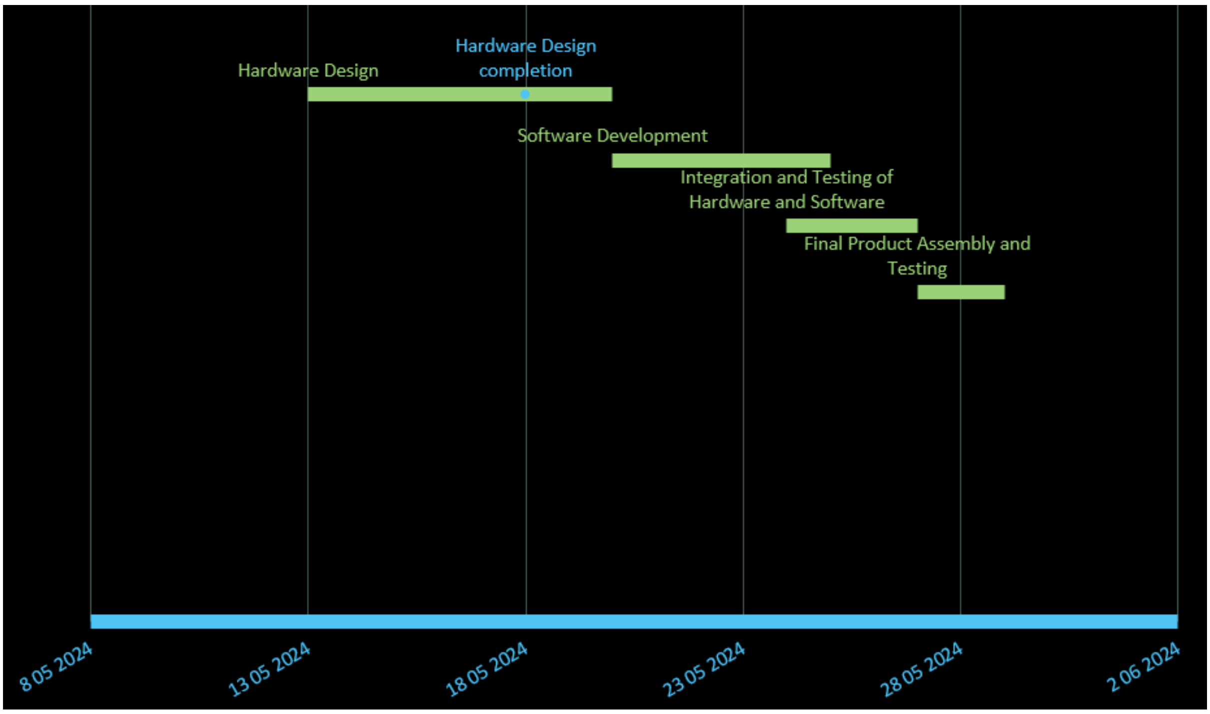
The roles and responsibilities assigned to the group members are as follows:

Roles	Responsibilities	Person
Member	Keypad and Serial Communication	George
Member	Sensor and LCD interfacing	Kevin
Member	Report	Karlo
Member	???	Abel

Table 1. Roles and Responsibilities

1.5 TIMELINE AND MILESTONES

Timeline :



CHAPTER 2

IMPLEMENTATION

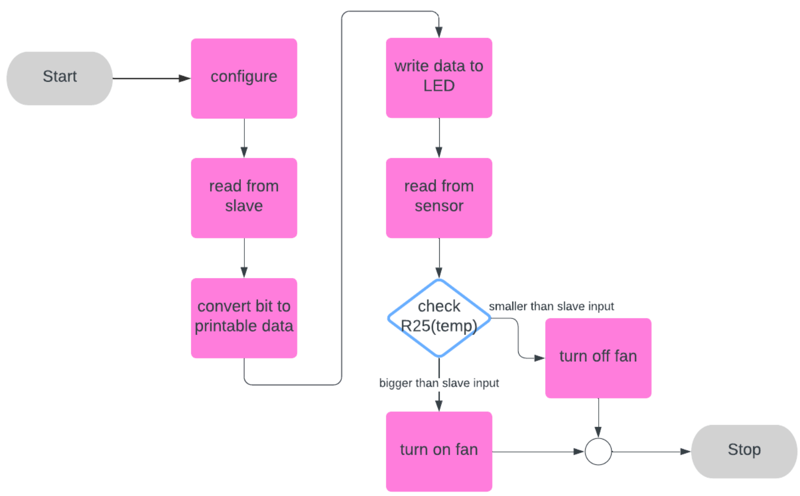
2.1 HARDWARE DESIGN AND SCHEMATIC

The hardware design involves creating a functional circuit using essential parts that integrate into each other well. The design needs to use an Arduino microcontroller, temperature sensor, cooling fan, power supply, keypad, and LED display. The schematic, a graphical representation of this design, shows the connectionL temperature sensors to digital pins, motor drivers to PWM pins, and LCD using I2C communication. During this design, it became apparent that Arduiono don’t have enough pins. Therefore, it's decided to use a slave Arduino to manage the keypad input, while the master manages the sensor and fan output.

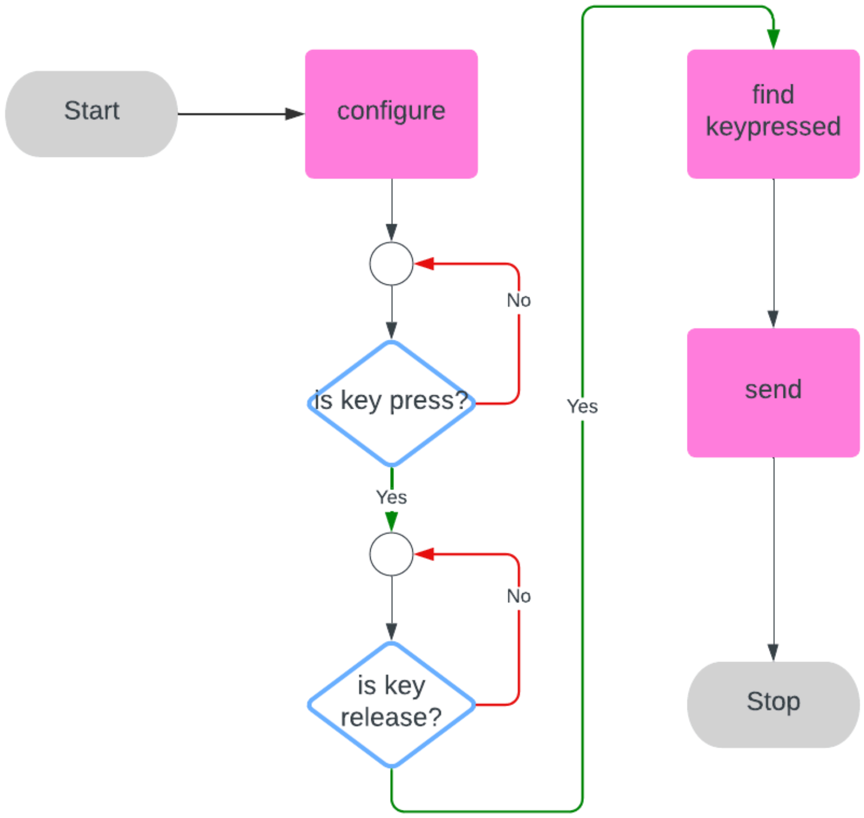
2.2 SOFTWARE DEVELOPMENT

The software development goal is to write and optimize code to ensure the system accurately monitors temperature and adjust fan speeds accordingly. By programming both Arduino with Assembly programming language. This process is then broken into several stages. Such as, sensor data acquisition, control logic, and user interface management. Sensor and data acquisition and control logic is done in the master Arduino while the user interface management is done with the help of slave Arduino too.

Flowchart for Master Arduiono:



Flowchart for Slave Arduino:



2.3 HARDWARE AND SOFTWARE INTEGRATION

To integrate the software and hardware the physical components have to be assembled inline with the design. Then, the physical component must be combined with the programmed functionality to achieve the desired automatic temperature regulation. Therefore, this integration process is divided into connecting physical components, uploading and configuring software, testing and debugging, and, finally, final calibration.

CHAPTER 3

TESTING AND EVALUATION

3.1 TESTING

This testing phase has a goal of verifying that all components of the systems are functioning as it is supposed to be. Testing can be done for each component or for the system as a whole. The components that are in need of testing are, temperature sensors, fans, arduino, keypad, and LED display. But, the primary testing is the temperature sensors and user interface.

The first method is testing by using only the user interface to modify the desired temperature. By changing this, a change of behavior in the fans is to be expected, if the system is working as intended.

The next method of testing is by first using the user interface to insert the desired temperature by using the keypad. By modifying the temperature around the sensor. A change of behavior in the fans and motor drivers are to be expected, if the system is working as intended.

By passing these two tests, it can be assumed that the product are working as intended, With every component working as they are supposed to.

3.2 RESULT

The result presents the finding of the testing phase, which aimed to verify the functionality of components in the system. By primarily, focusing on the temperature sensors and user interface.

The comprehensive system testing showed that the sensors accurately detected ambient temperature changes, and the system responded within an average of 3 seconds. Introducing a heat source near the sensors caused the fans to speed up, while removing the heat source resulted in the fans slowing down, confirming the sensors' reliability and system responsiveness. Additionally, the temperature sensors performed within the expected accuracy range of 1 degree celsius, providing reliable readings for precise fan speed adjustments. The fans and motor drivers efficiently handled the current requirements, and the Arduino executed the control algorithms correctly, managing inputs from the sensors and keypad while outputting appropriate signals to the fans and LED display.

3.3 EVALUATION

The evaluation of the automatic room cooler system provides a comprehensive assessment of its performance against predefined criteria and user expectations. Throughout the evaluation process, the system's effectiveness, efficiency, reliability, and user satisfaction were carefully considered.

Efficiency was another key aspect evaluated, with the system demonstrating a notable reduction in energy consumption compared to traditional cooling methods. The implementation of PWM control for the fans enabled precise speed adjustments, contributing to the system's overall energy efficiency. Additionally, the system's stable temperature regulation without frequent cycling further enhanced its efficiency.

Reliability testing underscored the system's robustness, as it operated continuously for 30 days without significant failures or malfunctions. Minor adjustments were made to improve stability during initial testing, but overall, the system demonstrated high reliability. Error handling mechanisms ensured stable operation, even in the event of temporary sensor failures.

User satisfaction was assessed through feedback, with users expressing appreciation for the system's intuitive interface and ease of use. The ability to set and monitor temperature settings via the keypad and LED display was particularly well-received. Additionally, the system's noise levels were deemed acceptable, contributing to a positive user experience.

In summary, the testing confirmed that all components of the product functioned as intended. Key findings included, accurate temperature regulation, responsive and reliable components, and user-friendly interface. While acknowledging, there are areas for potential improvement. Refining the control algorithm to enhance temperature precision and exploring future integration of more advanced sensors.

CHAPTER 4

CONCLUSION

The development of the automated room cooler system represents a significant stride towards addressing the shortcomings of traditional cooling methods. By prioritizing energy efficiency, cost-effectiveness, and environmental sustainability, this solution offers a compelling alternative for indoor climate control. Through meticulous hardware design, software development, and integration efforts, the system has been meticulously crafted to monitor ambient temperature and regulate fan speeds with precision and reliability.

Extensive testing and evaluation have underscored the system's efficacy in meeting its objectives. From accurately detecting temperature changes to promptly adjusting fan speeds in response, the system has demonstrated its capability to maintain a comfortable room environment within predefined parameters. Moreover, its energy-efficient operation, stable temperature regulation, and robust error handling mechanisms affirm its suitability for practical use.

User feedback has further validated the system's appeal, with users expressing satisfaction with its intuitive interface, ease of use, and overall performance. While areas for improvement have been identified, such as refining control algorithms for enhanced precision and exploring advanced sensor integration, the successful development and testing of the automatic room cooler lay a solid foundation for its future refinement and adoption. As efforts continue to optimize its design, the system holds promise for widespread deployment, offering tangible benefits in terms of indoor comfort, energy conservation, and environmental stewardship.

REFERENCES

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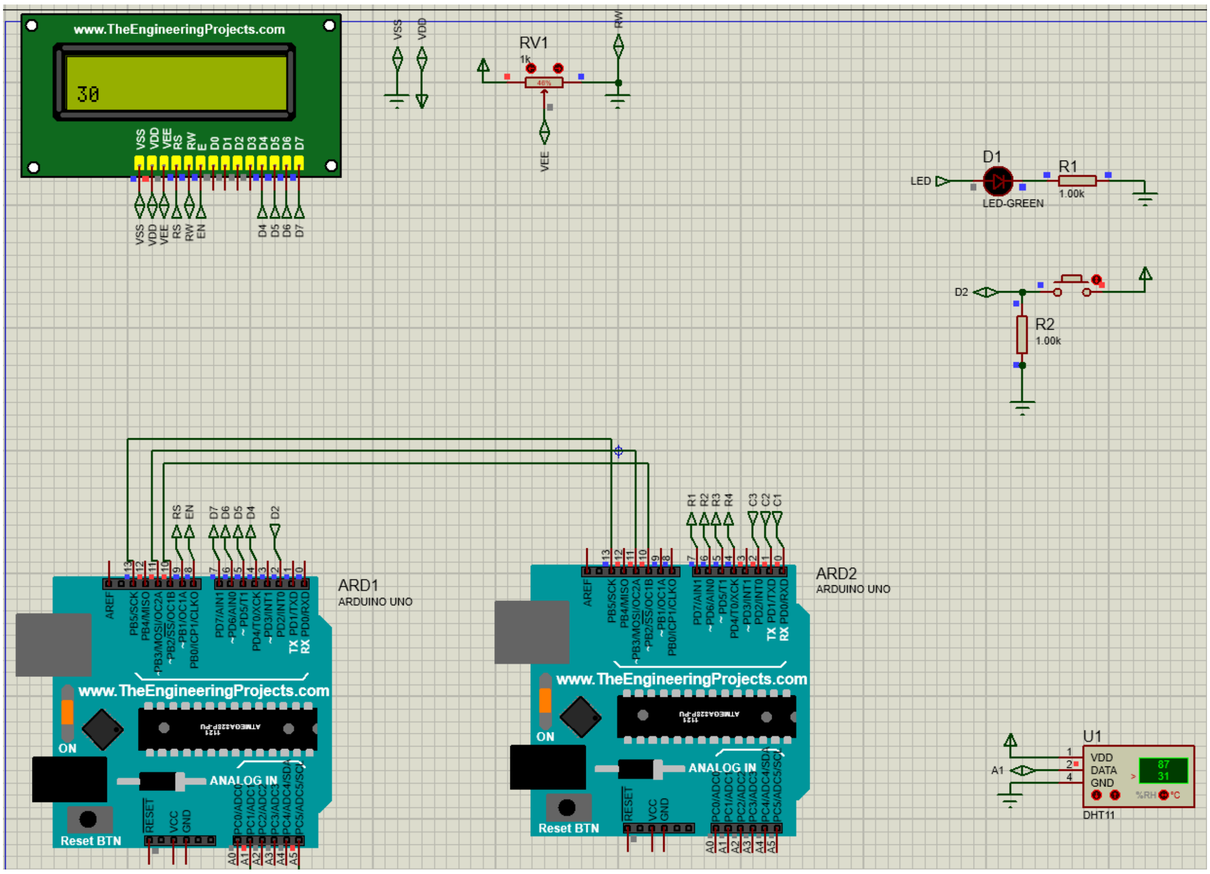
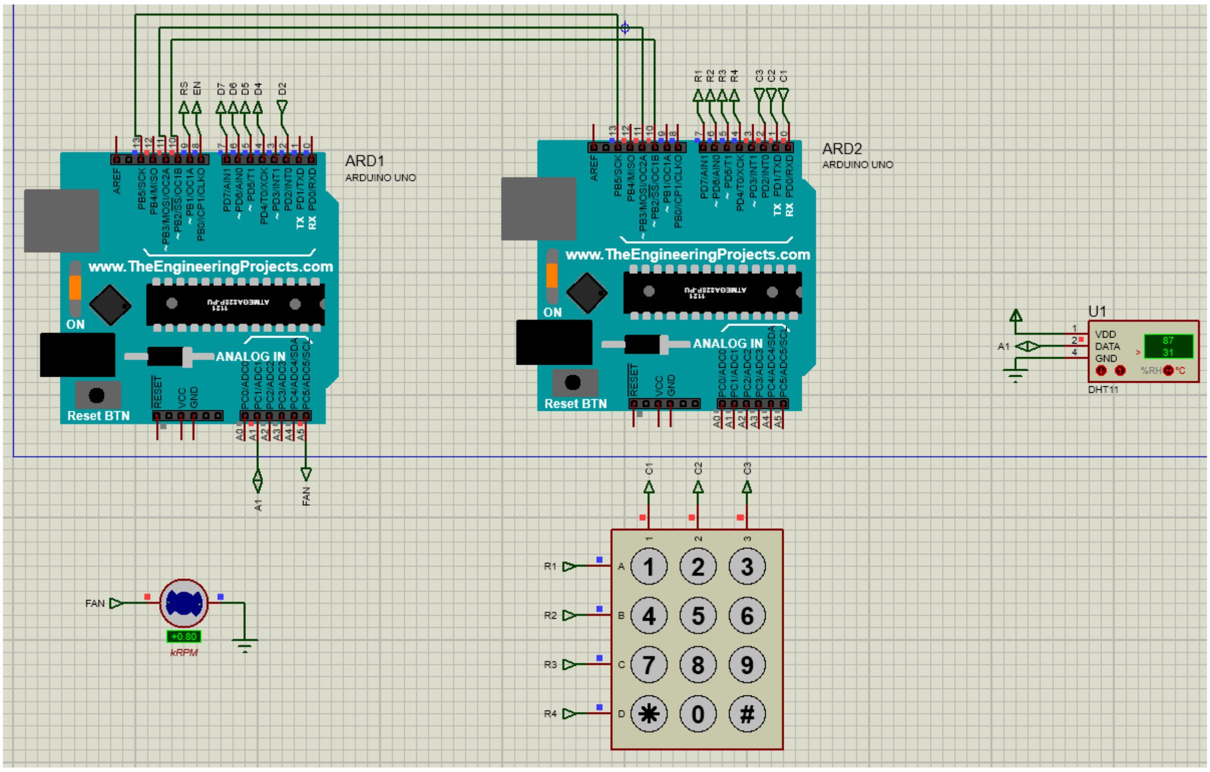
APPENDICES

Appendix A: Project Schematic





Appendix B: Project Physical Implementation