Ministry of Education and Science of Ukraine
Ternopil Ivan Pul'uj National Technical University
(full name of higher education institution)
Faculty of Computer Information Systems and Software Engineering
(faculty name)
Computer Systems and Networks Department
(full name of department)

Qualifying Paper
for diploma project (thesis)

Bachelor
(educational-proficiency level)

topic: *Комп'ютеризована система віддаленого керування програмованим термостатом*

The computerized remote control system for a programmable thermostat

Submitted by: fourth year student group ICI-42

Specialism (field of study)

123 «Computer Engineering»
(code and name of specialism (field of study))

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Ternopil
2023

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APPROVED BY
Head of Department *Halyna Osukhivska*

Assignment

FOR DIPLOMA PROJECT (THESIS) FOR STUDENT

Ogbera Emuesiri Gabriel
(surname, name, patronymic)

1. Project (thesis) theme. *The computerized remote control system for a programmable thermostat*

Project (thesis) supervisor *Yurii Leshchyshyn, PhD*
(surname, name, patronymic, scientific degree, academic rank)

1.Approved by university order as of *20.04.2023 № 4/7-404*
2. Student's project (thesis) submission deadline 13.07.2023
3. Project (thesis) design basis *Technical assignment*

4. Contents of engineering analysis (list of issues to be developed)
Introduction
1. Analysis of the technical task
2. Project part
3. Practical part
4. Life safety, basics of labor protection
Conclusions

5. List of graphic material (with exact number of required drawings, slides)
1. Structural diagram
2. Basic electrical scheme
3. Diagram of electrical connections
4. Block diagram of the program algorithm

6. Advisors of design (thesis) chapters

Chapter	Advisor's surname, initials and position	Signature, date	
		assignment given	assignment accepted
Life Safety			
basics of labor protection			

7. Date the assignment was given *20.04.2023*

PROJECT TIME SCHEDULE

LN	Diploma project (thesis) stages	Project (thesis) stages deadlines	Notes
1	*Development and approval of the technical assignment*	*20.04 – 28.04*	*Done*
2	*Analysis of the technical task and justification of the possible*	*20.04 – 30.05*	*Done*
	solutions		
3	*Development of a structural and functional scheme*	*18.05 – 30.05*	*Done*
4	*Selection of element base*	*18.05 – 30.05*	*Done*
5	*Development of software for the designed*	*18.05 – 30.05*	*Done*
	systems		
6	*Elaboration of the issues of the section "Security*	*20.05 – 25.05*	*Done*
	life activities, basics of labor protection"		
7	*Completion of the explanatory note of the qualification work*	*18.05 – 30.05*	*Done*
8	*Designing the graphic part*	*21.05 – 23.06*	*Done*
9	*Preliminary defense of a bachelor's thesis*	*04.06 – 28.06*	*Done*
10	*Defense of the bachelor's thesis*	*13.07*	*Done*

Student ____________ *Ogbera Gabriel*
(signature) (surname and initials)

Project (thesis) supervisor ____________ *Yurii Leshchyshyn*
(signature) (surname and initials)

ABSTRACT

The computerized remote control system for a programmable thermostat // Bachelor's work // Ogbera Gabriel Emuesiri // Ivan Pulyuy Ternopil National Technical University, Faculty of Computer Information Systems and Software Engineering, Department of Computer Systems and Networks, СІзс-42 Group // Ternopil, 2023 //

Key words: Wi-fi, Arduino, HVAC.

The bachelor's thesis consists of four sections.

The first section describes the Analysis of the Wi-Fi thermostat, it connection using BLYNK.

The second section describes the process of designing Wifi thermostat and the justification of the hardware and software.

The third section performs software implementation and testing of a Wifi thermostat

The fourth section describes the issues of life safety and the basics of labor protection.

Content

Introduction

A Wi-Fi thermostat, also known as a smart thermostat, can connect to your home's Wi-Fi network to operate and monitor your HVAC system remotely using a smartphone, tablet, or computer. It has more functionality than standard thermostats.

Wi-Fi thermostats allow remote HVAC system control. Remotely alter temperature, settings, and schedules from home or away. Adjusting the temperature to your preferences and occupancy patterns saves energy and keeps you comfortable. Wi-Fi thermostats often have smart scheduling. They can learn your heating and cooling tendencies and make customized programs. The thermostat can automatically adjust the temperature based on when you're home or away, saving energy and improving comfort. Wi-Fi thermostats save energy and money. They may provide HVAC energy utilization information and insights. They can also recommend energy-efficient settings or HVAC system optimization. Geofencing leverages your smartphone's location to identify whether you're home or away on several Wi-Fi thermostats. The thermostat can switch to energy-saving mode when you leave a certain region. It adjusts the temperature to your liking when you return. This feature saves electricity and makes coming home comfortable.

Wi-Fi thermostats commonly work with smart home systems. They provide voice control of the thermostat via Amazon Alexa or Google Assistant. Apple HomeKit and Samsung SmartThings allow you to automate routines and control your thermostat and other connected devices. Some Wi-Fi thermostats use weather forecasts to optimize HVAC operation. If the forecast calls for a warm day, the thermostat can start cooling your home early to stay comfortable. Wi-Fi thermostats provide previous energy usage statistics and reports. Tracking your energy consumption can reveal patterns or abnormalities. This data can influence energy-saving decisions and HVAC system difficulties. Wi-Fi thermostats are convenient, save energy, and improve home comfort. It optimizes your HVAC system, reduces energy waste, and creates a personalized heating and cooling plan based on your preferences and daily habits.

CHAPTER 1 ANALYSIS OF TECHNICAL TASK

1.1 Analysis of the Wi-Fi Thermostat

My goal for this advanced Wi-Fi programmable room thermostat with an integrated air quality monitor is to maximize comfort, energy economy, and indoor air quality. Analyser and contactor are the main component. The analyser receives sensor signals, generates control signals, and displays pertinent information. The contactor adjusts the heating equipment or system based on analyser signals. I appreciate that the thermostat nodes can communicate wirelessly through radio frequency. Wireless connectivity simplifies room heating control. Temperature control enhances day-long comfort. The thermostat keeps three set temperatures to meet different requirements and preferences throughout the day. This dynamic temperature control provides the optimum combination of warmth and cooling throughout the day. Remote Wi-Fi setting improves user ease. Remotely configure thermostat settings, work routines, and air boundary parameters via a browser-based interface. Wi-Fi connectivity simplifies temperature threshold adjustments and heating schedule customization.

I included an air quality monitor to emphasize indoor air quality. This monitor measures temperature, CO2, and humidity. It can assess room air quality by regularly monitoring these factors. This feature is ideal for people who value a healthy living environment and wish to maintain high air quality. The real-time clock (RTC) syncs with an accurate time server through the internet. This synchronization guarantees accurate timekeeping and scheduling for day-to-day temperature control and automation. The Blynk smartphone app lets users monitor and control the thermostat. Users may watch, adjust, and engage with it via the app. The app provides real-time information and control.

It maintains temperature management and monitoring even when the Wi-Fi is down. If connectivity fails, this protects comfort and air quality. The wifi thermostat provides threshold notifications. It can send email alerts if temperature, CO2, or air humidity exceed predefined thresholds.

This function alerts users to substantial deviations from the desired circumstances so users can act. It can manage humidity and CO_2 levels in addition to temperature. This provides automatic humidification, forced ventilation, or air conditioning based on room and occupant needs. It operates year-round. After the heating season, it sends email updates on temperature, humidity, and CO_2 concentration.

The analyser device includes the NodeMCU CP2102 ESP8266 Wi-Fi board, DHT22 temperature and humidity sensor, MH-Z16 CO_2 sensor, DS3231 real-time clock, OLED LCD screen, RF module (433MHz), and LM7805 voltage stabilizer. These components are carefully integrated for reliable performance and accurate measurements. This is a cutting-edge Wi-Fi-enabled thermostat with air quality monitoring, temperature control, and energy efficiency. Its enhanced capabilities, smooth wireless communication, and easy control options will transform how people manage comfort and air quality in their home or office.

1.2 Analysis of the common WiFi thermostat

WiFi thermostats combine innovative technology with user-friendly features to transform home heating and cooling. Smartphone apps or web portals let homeowners remotely control and monitor their HVAC systems.

Figure 1.1- A WiFi thermostat

This review will examine common WiFi thermostats' functionality, benefits, energy-saving capabilities, compatibility, and consumer considerations. WiFi thermostats include several comfort, convenience, and energy-saving functions. First, they provide remote temperature control and scheduling. Based on occupancy trends, some models use machine learning algorithms to modify temperature settings to users' preferences. Most WiFi thermostats have easy smartphone apps with real-time status updates, energy consumption information, and maintenance alarms. These apps allow users to monitor and alter HVAC settings remotely, giving them more control. Some thermostats can also sync temperature settings with smart home devices like smart lighting and blinds.

WiFi thermostats save energy. These gadgets enable remote access and intelligent scheduling to improve HVAC energy use. If they fail to switch off the AC or heat before leaving, homeowners can alter the temperature remotely. WiFi thermostats can also adapt to users' habits. These gadgets use occupancy sensors and machine learning algorithms to automatically regulate the temperature in deserted homes to save energy. Some WiFi thermostats also provide energy reports to assist homeowners improve their energy usage and make informed decisions. A WiFi thermostat must work with existing HVAC systems. Most WiFi thermostats work with central HVAC, heat pumps, and radiant heating systems. Before buying, check HVAC compatibility.

WiFi thermostats replace current thermostats and require simple electrical skills to install. The installation method entails turning off the HVAC system, removing the old thermostat, connecting the cabling to the new thermostat, and configuring the device via the smartphone app or web interface. Some manufacturers offer professional installation services. WiFi thermostats have many benefits, but customers should consider several issues before buying one. WiFi thermostat prices vary by brand, model, and features. Some costlier models provide greater features and energy savings. Second, connectivity matters. WiFi thermostats need a steady WiFi network for remote access and control. Users should check their home network's coverage and capacity to ensure the thermostat works well. Finally, each connected gadget should be secure and private. WiFi thermostats from trustworthy manufacturers who focus data security and provide firmware upgrades to fix vulnerabilities are best.

WiFi thermostats have revolutionized household heating and cooling. These products improve comfort, convenience, and energy efficiency with remote access, intelligent scheduling, energy monitoring, and smart home ecosystem compatibility. Before choosing a WiFi thermostat, buyers should evaluate compatibility, installation, cost, connectivity, and security. Homeowners may optimize their HVAC systems and enjoy a connected, energy-efficient home with research and consideration.

1.3 Overview of the connection via BLYNK, as the main way of communication between the user and the system

Blynk is a mobile app for remotely controlling and monitoring Arduino and other similar hardware projects. Blynk makes designing bespoke control interfaces and dashboards for IoT projects easy. It lets you construct a mobile app interface to control and monitor your hardware project remotely. Blynk is free for iOS and Android. App retailers offer it. Set up the Blynk server and configure your project in the app to connect the app to your hardware project. Blynk lets you build many projects for each hardware setup or application. When building a project, you can choose a hardware platform (e.g., Arduino) and connectivity (Wi-Fi, Ethernet, Bluetooth, etc.) to communicate with the Blynk app.

Blynk offers many pre-built widgets for project dashboards. Widgets represent app controls and displays. Widgets include sliders, graphs, gauges, LCD displays, and more. These widgets' appearance and functionality can be customized for your project. Each Blynk app widget represents a hardware project function or value. You can set user-interaction actions for widgets. A button widget can turn on a motor or change a setting in your hardware project.

Blynk lets you visualize real-time hardware project data via graphical widgets. Graphs, gauges, and LCD displays can show sensor readings, log data, and other pertinent information. This allows remote project monitoring and analysis. Blynk uses virtual pins to connect the app to your hardware project. Virtual I/O pins send and receive data. A widget can be linked to a virtual pin and its data format is defined. This makes project management flexible and scalable. Blynk's event-driven programming style lets you manage app events in your hardware project's code. Your project's behavior and responsiveness to these events can be controlled interactively. Blynk uses energy to control app resources and capabilities. Widgets and interactions use energy. Additional energy can be purchased for Blynk's free version. Subscription options give more features and energy. Blynk connects your hardware project to its cloud servers for safe app-project communication. The software and hardware communicate via Blynk servers. This lets you manage your project from any internet-connected location. Blynk's active developer and user community shares projects, code, and ideas. The Blynk app works with several IoT platforms and protocols. This lets you use libraries and resources to improve projects. For managing and monitoring Arduino and other IoT projects, the Blynk app is simple and configurable. Blynk simplifies remote control interface development with its wide widget library, real-time data display, and event-driven programming style. Blynk cloud servers allow you to access and interact with your hardware project from anywhere, making it suitable for IoT applications.

CHAPTER 2 PROJECT PART

2.1 Development of the generalized structure of the computer system

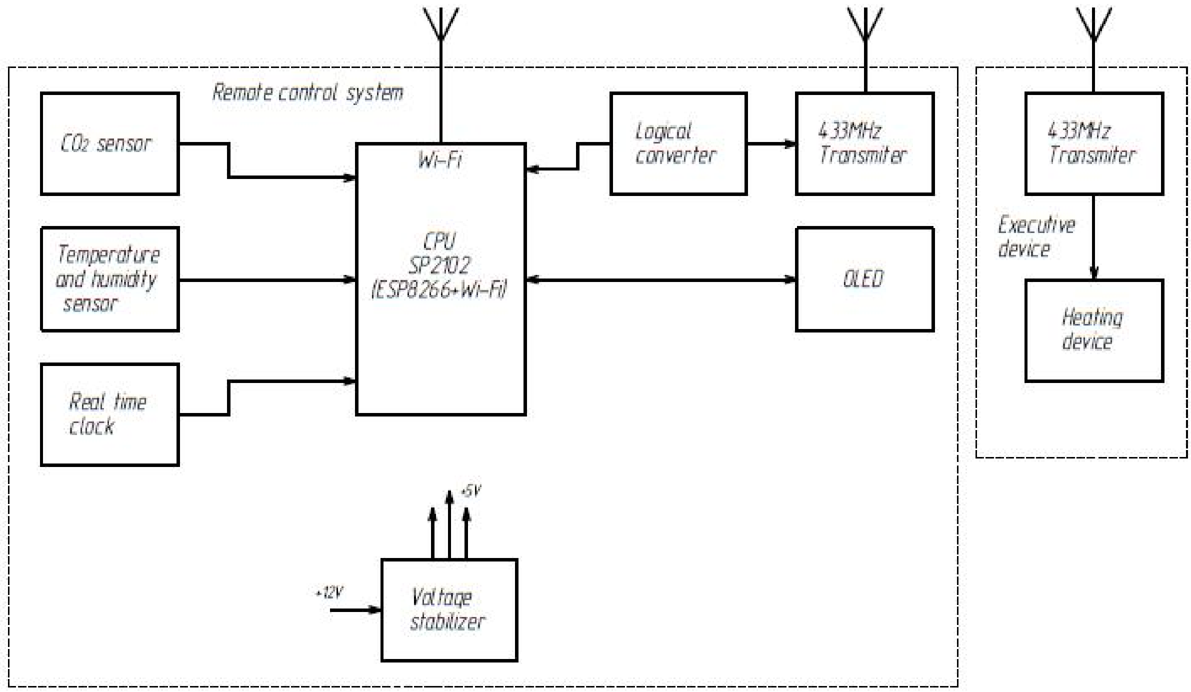

Figure 2.1- The Structure of the Computer System

The analyser brain is an ESP8266 controller on the NodeMCU CP2102 module board. Sensor signals control the transmitter and screen. Install the DHT22 temperature and humidity sensor on the board away from heat-dispersing elements to reduce temperature measurement mistakes. Heatsink the LM7805 voltage regulator to manage the temperature. Connect DHT22 to NodeMCU CP2102 module D6. I2C-connect the DS3231 clock module and 0.96" OLED display to the ESP8266. Connect the ESP8266 Rx and Tx pins to the MH-Z19 CO2 sensor. The AC/DC converter supplies 12V DC to the analyzer, while the LM7805 generates a stable 5V for the transmitter and other components.

Contactor: Analyser signals control the heat source's contactor. Connect the RF receiver module to the Arduino Pro Mini 5V module. Connect the relay module open relay contacts to the heater power circuit and the HLK-PM01 AC-DC adapters power the contactor. Check connections and wiring. After assembling the analyser and contactor, turn on the thermostat.

Turn the analyser on and let it steady for a few minutes. The OLED panel displays air parameters after start-up. Turn off and on the analyser's AC/DC adapter to set up Wi-Fi and other settings. This puts the device in configuration mode, denoted by an access point named "am-5108."Use the "am-5108" password to connect to a computer or smartphone. Visit http://192.168.4.1 to view the configuration page.

Enter your home network name (SSID), password, Blynk identification key, email address, time zone, time points, temperature control settings, and threshold values for temperature, humidity, and CO2. The ESP8266 will restart with the saved settings. After configuring the analyser, activate the contactor: Use the proper AC-DC adapter (HLK-PM01) to power the contactor device. The contactor's connections to the RF receiver module and relay module should be secure and correctly wired. Start the contactor. The analyser and contactor device should have a steady radio connection for smooth communication.

The contactor's Arduino board's D13 LED blinks when connected. Check RF modules, antennae, and analyser-contactor connections if the LED does not flicker or blinks irregularly. The analyser signals the contactor to regulate the heating device or system. The contactor activates or deactivates the heating device to maintain the thermostat's predetermined temperature. Blynk mobile app remote monitoring and control: Install the Blynk smartphone app from the app store. Launch the app and register if necessary. The Blynk identification key connects the app to your thermostat. Monitor and control the thermostat remotely after connecting: Blynk displays real-time temperature, humidity, and CO2 levels. The easy interface manages thermostat settings like temperature setpoints and time schedules. Analyser historical temperature, humidity, and CO2 levels. Blynk offers data logging, graphing, and event triggers. Email alerts: The thermostat checks temperature, humidity, and CO2 levels against predefined thresholds. The thermostat will email the supplied address if any of these metrics surpass their thresholds. Email alerts for abnormal situations let you maintain a comfortable and healthy interior environment.

2.2 Description of electrical schematic

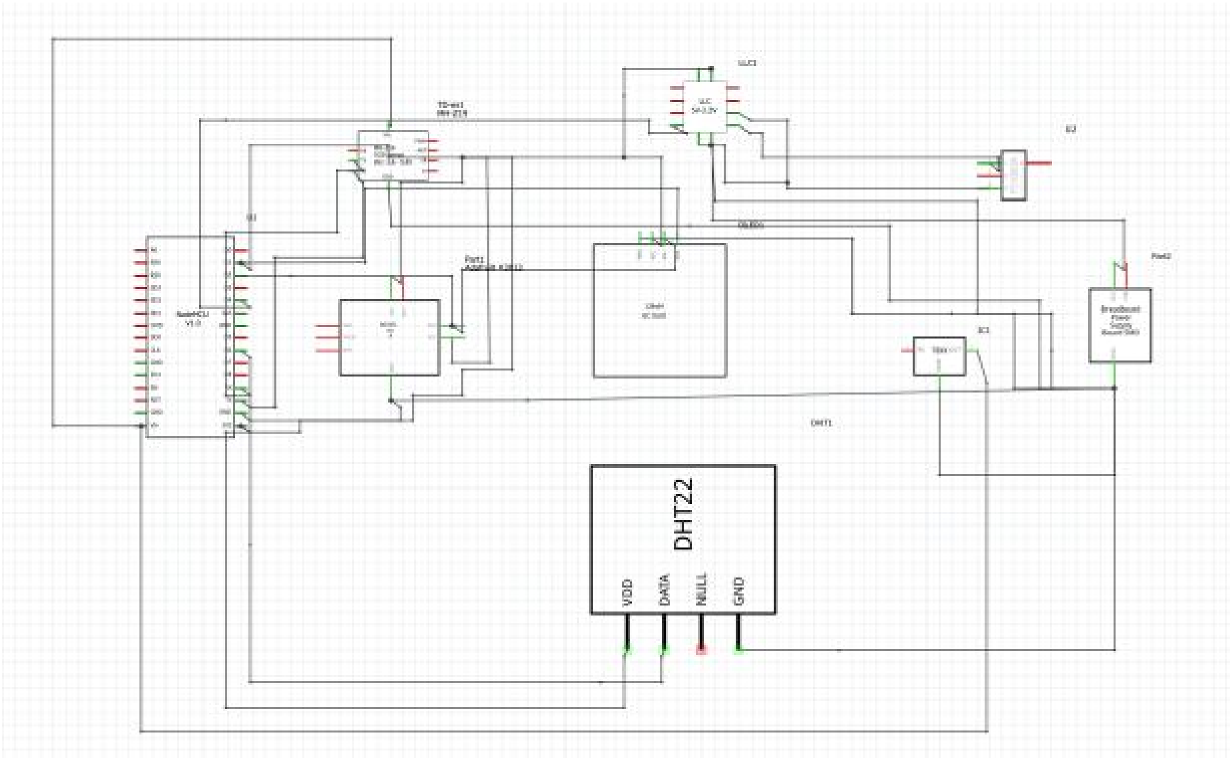

Figure 2.2 – Electrical Schematic of Analyser

Node MCU CP2102 module D6 connects the DHT22 sensor. This pin accepts data. DHT library communication between ESP8266 controller and DHT22 sensor. This library reads sensor temperature and humidity. Data acquisition begins when the ESP8266 controller signals the DHT22 sensor. DHT22 sensors report temperature and humidity to the ESP8266 controller. The ESP8266 controller processes and analyses the data. ESP8266's Tx and Rx pins connect the MH-Z19 CO2 sensor. Software Serial connects the ESP8266 controller to the MH-Z19 sensor. Software Serial emulates serial ports on ESP8266 GPIO pins. The ESP8266 controller connects the MH-Z19 sensor's Rx and Tx pins to one of these GPIO pins. The ESP8266 controller requests CO2 data from the MH-Z19 sensor through the Tx pin. The Rx pin of the MH-Z19 sensor sends CO2 data to the ESP8266 processor. CO2 data is sent to the ESP8266 controller for analysis. I2C connects the ESP8266 controller to the DS3231 RTC module.

I2C uses SDA and SCL cables to communicate between numerous devices. ESP8266 is the I2C controller, and DS3231 is the peripheral device. The ESP8266 controller starts communication by delivering an SDA start signal and the DS3231 module's address. The ESP8266 controller may then read the time and date from the DS3231 module and synchronize its internal clock. ESP8266 controllers process and evaluate sensor data. It may calculate average temperature, humidity, and CO2 levels over time. To determine action, the controller might compare measured values to established thresholds or desired settings. The controller may activate the heating device or system if the temperature is below the desired range or change the ventilation if CO2 levels are too high based on the analysis.

Based on the analysis, the ESP8266 controller provides transmitter and screen control signals. The controller sends wireless transmitter control signals. The heating system contactor or relay receives these impulses. The transmitter controls the heater's on/off switch. The ESP8266 controls the OLED LCD screen through I2C. It updates the screen with commands and data. The controller can display temperature, humidity, CO2 level, thermostat mode, notifications, and warnings. The controller displays essential information on the screen. The ESP8266 controller receives sensor data, processes and analyses it, and generates transmitter and screen control signals. It collects sensor readings, analyses them, and takes action based on the data using specialized libraries and communication protocols. The transmitter controls the heating equipment or system using the control signals and updates the OLED LCD screen with necessary information.

The contactor device controls (Figure 2.3) the heating equipment or system via RF receiver signals. The contactor gadget has numerous interconnected parts. It has an Arduino Pro Mini 5V module, a 433MHz receiver, and a 2-channel relay module. These components efficiently receive, process, and act on signals. Arduino Pro Mini: RF receiver module. It connects the analyzer's RF transmitter to the contactor device's control system. The analyser and contactor communicate reliably since the RF receiver receives signals wirelessly at 433MHz.

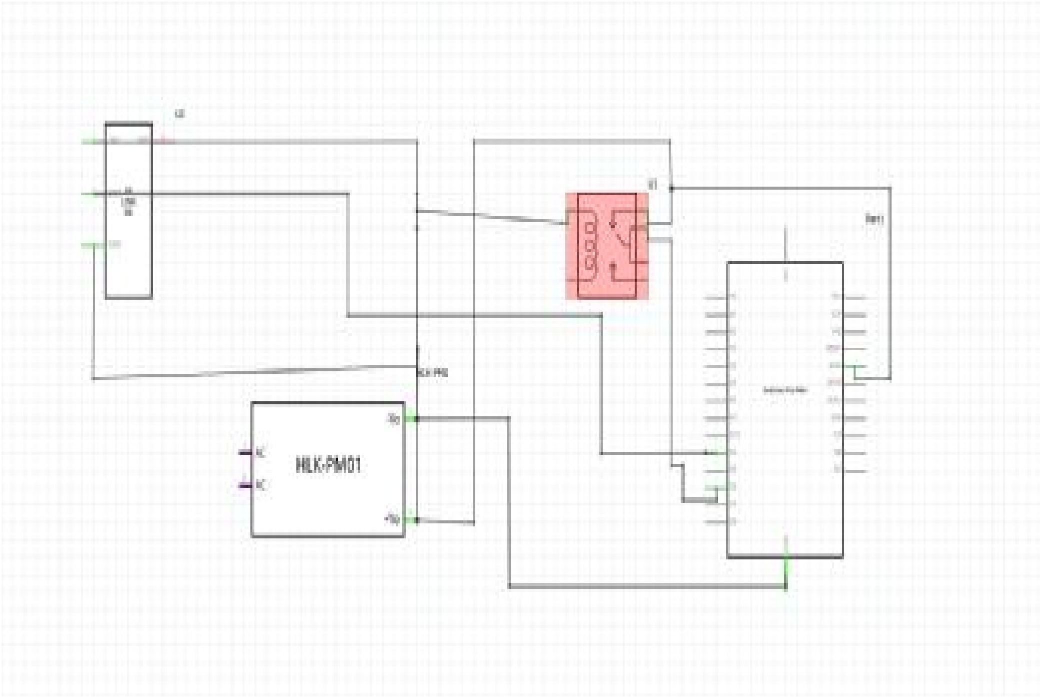

Figure 2.3 – Electrical Schematic of Contractor

The Arduino Pro Mini decodes the signal captured by the RF receiver. The contactor device's brain decodes signals and extracts relevant information. The modulation system, data packets, and air parameter threshold values are analyzed during decoding. The decoded signal contains vital air parameter threshold data from the Wi-Fi programmable room thermostat. Temperature, humidity, and CO2 levels are set by these criteria. The thermostat lets users select these levels based on comfort and energy economy. The Arduino Pro Mini compares the decoded threshold values to real-time air parameter measurements. The thermostat system's analyzer device has DHT22 temperature and MH-Z19 CO2 sensors. The contactor device receives reliable data from these sensors. The Arduino Pro Mini's programmed logic uses comparison results to decide control actions. The Arduino Pro Mini sends control signals when air parameters surpass criteria. The Arduino Pro Mini closes a relay module to activate the heating unit if the temperature exceeds the threshold.

The 2-channel relay module relays Arduino Pro Mini control signals. Electromechanical relays are electrically controlled switches in relay modules. The heating device activates when the relay closes its relay contact. This mechanism controls and adjusts a heater, boiler, or other heating system based on real-time air quality. The contactor device continuously monitors air parameter measurements from the analyzer device. The contactor gadget monitors measurements for changes. The contactor device stays in its current state if all air parameters are within threshold limits. If any parameters exceed their thresholds, the contactor device provides fresh control signals to adjust the heating device and return air parameters to the required ranges.

The analyzer and contactor communicate wirelessly. The analyzer's RF transmitter wirelessly transfers signals to the contactor's RF receiver. Remote control of the heating system is easy and dependable using this wireless connection at 433MHz. It integrates and simplifies the thermostat system by eliminating physical connections. Based on the Wi-Fi programmable room thermostat's air parameter thresholds, the contactor device controls the heating device or system precisely. This sophisticated system optimizes the heating system based on real-time air quality, temperature, and humidity. It improves comfort, energy efficiency, and sustainability in regulated spaces.

2.3 Description of connection schematic

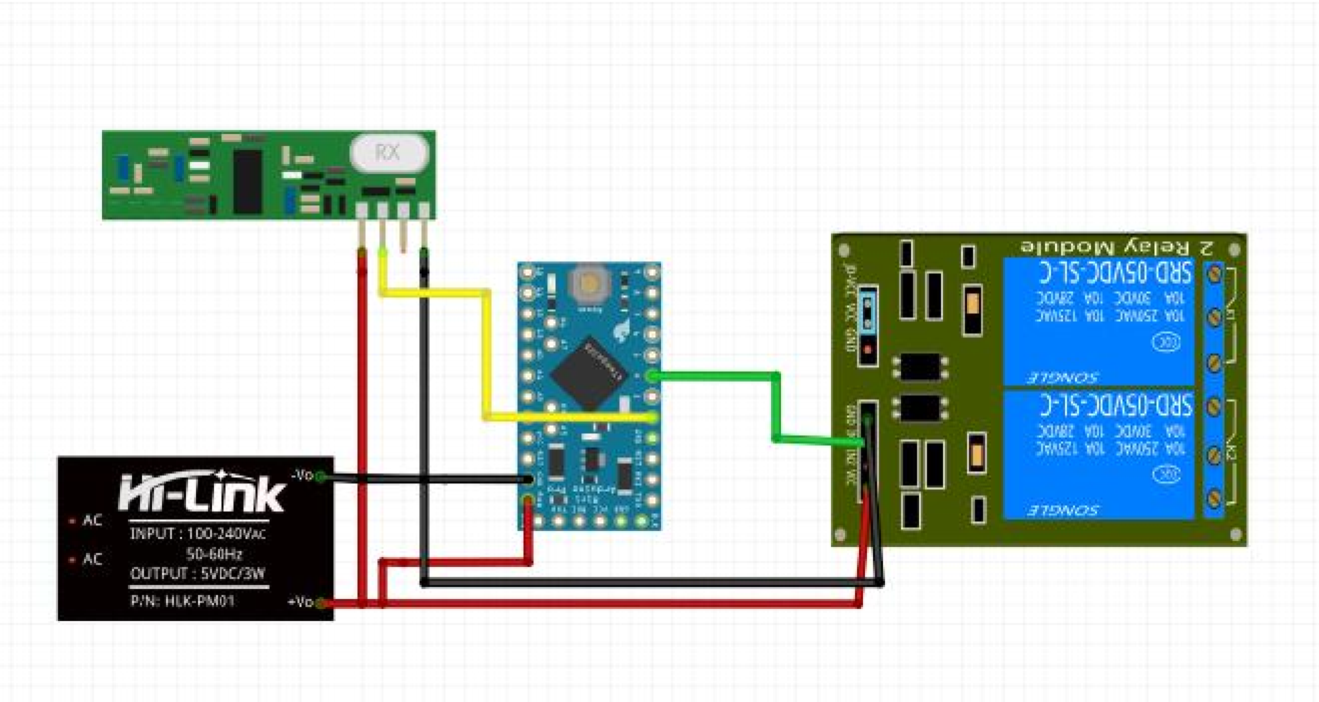

Figure 2.4 – Connection Schematic for Contractor

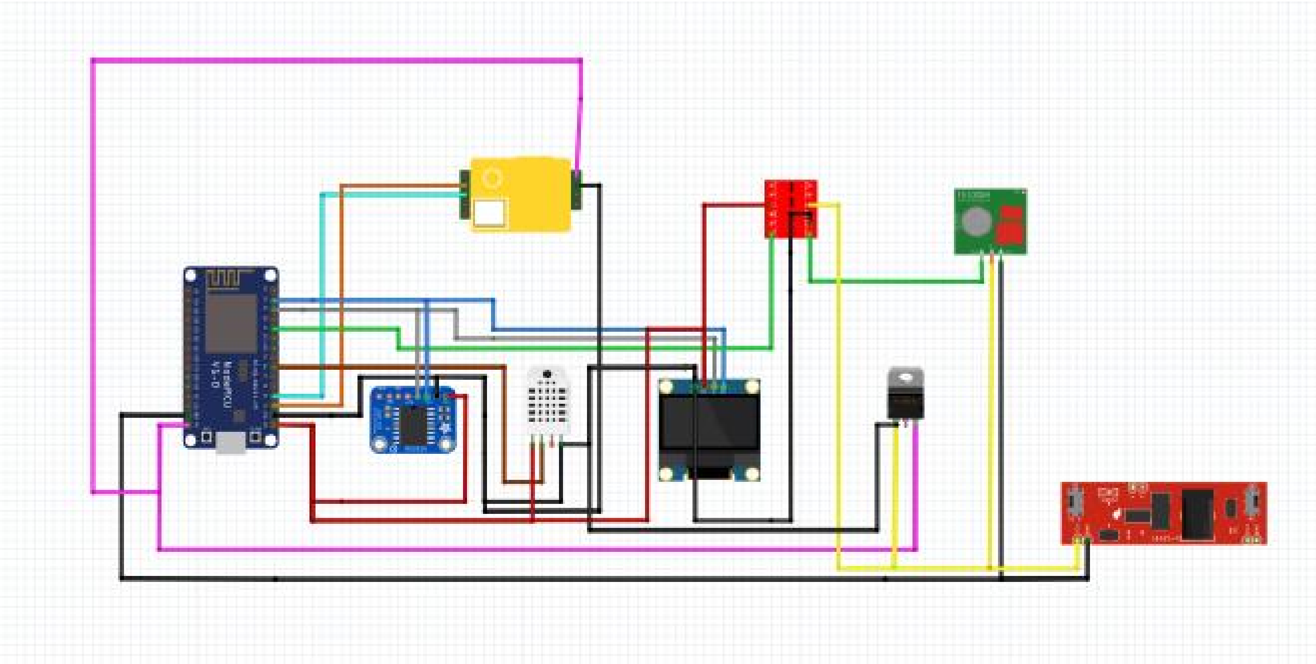

Figure 2.5 – Connection Schematic for Analyser

This is the connection schematics for both thermostat main parts. This shows the analyser and contractor. The analyser uses the DHT22 temperature and humidity sensor. However, recorded temperatures are slightly greater than actual temperatures. To avoid this issue, place the DHT22 sensor away from board heat sources. Temperature and humidity sensors include the DHT22. The sensor measure temperature and humidity more accurately and reliably. The LM7805 DC voltage regulator converts the 12V supply voltage from an AC/DC adapter to a stable 5V output. Installing the LM7805 on a heatsink helps disperse heat. The ESP8266-based NodeMCU CP2102 module is an integrated development board. It controls the analyser and provides Wi-Fi. The NodeMCU CP2102 module powers components and stabilizes 3.3V power sources for other circuit nodes. The MH Z-19 sensor measures CO2 in the atmosphere. It sends CO2 data to the ESP8266 microprocessor through the Rx and Tx pins. Analyzer timekeeping is accurate using the DC3231 clock module. Disconnecting the battery charging circuit in the clock module prevents battery swelling. The clock module has a 2-second-per-year accuracy when powered separately. The two-wire I2C interface connects this display to the ESP8266 microprocessor. It displays temperature, humidity, CO2 levels, and time. The LM7805 voltage regulator provides a consistent 5V for the NodeMCU CP2102 module and the MH Z-19 CO2 content sensor from a 12V supply voltage. NodeMCU CP2102 module D6 pin connects the DHT22 temperature and humidity sensor. I2C connects the clock module, display, and ESP8266 microprocessor. The analyzer measures temperature, humidity, and CO2 with numerous components. The 0.96" screen displays precise data from the ESP8266 microcontroller and several sensors.

The contactor control relies on the Arduino Pro Mini module. RF receiver signals enable wireless device communication. These signals are processed by the Arduino Pro Mini module and output to exceed air parameter thresholds. AC/DC adapter HLK-PM01 powers contactor units with 5V. This provides power to the contactor components. The diagram's red and yellow wires connect to the heater power circuit's open relay contacts. Open relay contacts cut power to the heater, controlling its operation. The controller output signals activate air parameter threshold-based actions. Output 6, connected with humidity greater than the minimum threshold, can organize automatic humidification. This design eliminates the need to run wires to send sensor control signals to specific units. Instead, a contactor near one end of the power or system control wire can control power flow and activate desired actions based on predefined criteria. The Arduino Pro Mini module receives RF receiver signals and generates contactor control signals. The contactor, powered by the AC/DC adapter, regulates power to the heater circuit, and the controller outputs from the Arduino Pro Mini module trigger various actions based on predefined air parameter thresholds, allowing for automatic humidification, forced ventilation, or air conditioning without additional cabling.

2.4 Justification of the choice of hardware of the Wi-Fi thermostat

2.4.1 Wi-Fi board NodeMCU CP2102 ESP8266

The NodeMCU CP2102 ESP8266 Wi-Fi board is a popular IoT development board. The ESP8266 Wi-Fi module with CP2102 USB-to-serial converter allows for easy programming and device connectivity.

Figure 2.6 - NodeMCU CP2102 ESP8266

Its features and capabilities are mentioned here. The NodeMCU CP2102 board uses the ESP8266 Wi-Fi module, a microcontroller with Wi-Fi connectivity. The ESP8266 lets your thermostat connect to wireless networks and communicate with other devices and services online. The NodeMCU CP2102 has an 80MHz microprocessor. Its Tensilica Xtensa LX106 architecture provides enough processing power and memory to handle thermostat operations including reading sensor data, controlling outputs, and maintaining connectivity.

The inbuilt CP2102 chip makes NodeMCU board-computer communication easier. It turns the USB interface into a serial interface, allowing you to program the microcontroller and transfer data over USB. The NodeMCU CP2102 has GPIO pins for attaching sensors and other components. These pins support I2C, SPI, and UART protocols and can be used as digital inputs or outputs. The board has one analog input pin for measuring temperature and light intensity with analog sensors. This lets your thermostat add environmental sensors. The NodeMCU CP2102's breadboard-friendly design makes prototyping and connecting components easy. The connector and spacing match common breadboard layouts, easing thermostat circuit integration. The board has enough Flash memory (usually 4MB) for software code, web server files, and configuration data. This much storage lets you use advanced features and store thermostat data. A PC or USB charger can power the NodeMCU CP2102. Many applications no longer require an external power supply.

The NodeMCU CP2102 supports Arduino and the Arduino IDE. Using the Arduino library ecosystem and community support, this familiar programming environment makes code development and uploading easy. The NodeMCU CP2102 board's ESP8266 module supports 802.11 b/g/n Wi-Fi, allowing your thermostat to connect to local networks. This connectivity allows remote thermostat control and monitoring via smartphone apps, web interfaces, or smart home devices.

The NodeMCU CP2102 supports the MQTT protocol. IoT applications employ MQTT for efficient and reliable device connection. This allows the thermostat to seamlessly integrate with MQTT-based home automation platforms and cloud services.
NodeMCU CP2102 has a lively open-source community. This means you may discover many resources, tutorials, and example projects online to help you get started and troubleshoot any thermostat development challenges. The NodeMCU CP2102 ESP8266 board combines the ESP8266 Wi-Fi module, a powerful microprocessor, and simple development tools. Its extensive features and capabilities make it a great choice for developing a thermostat with additional functions and connectivity choices.

2.4.2 DHT22 temperature/humidity sensor

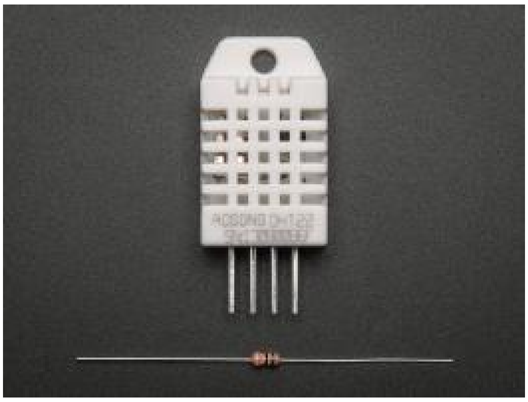

Figure 2.7 - DHT22

The popular and reliable DHT22 temperature/humidity sensor, commonly known as the RHT03, measures ambient temperature and relative humidity in numerous applications. Its exact readings make it useful for thermostats, weather stations, environmental monitoring systems, and more.

The DHT22 sensor measures temperature and relative humidity within ±0.5°C and ±2%, respectively. This accuracy ensures accurate thermostat temperature and humidity monitoring.

DHT22 sensor can sense ambient temperatures between -40°C and +80°C (-40°F to 176°F). The relative humidity sensing range is typically 0%–100%, making it useful for monitoring humidity in varied situations. DHT22 sensor communicates with microcontrollers and other devices via digital output. DHT, a single-wire protocol, simplifies sensor installation and integration into your thermostat circuit. Capacitive humidity and digital temperature sensors make up the DHT22 sensor. The capacitive humidity sensor detects relative humidity by sensing water vapor-induced capacitance changes, whereas the temperature sensor measures the correct temperature. The DHT22 sensor uses less power, making it ideal for battery-powered applications. Its low-power standby mode and low-power measurement mode let your thermostat's power source last longer.

DHT22 sensor provides near-instantaneous temperature and humidity readings. Real-time environmental monitoring and control require this speedy response. The DHT22 sensor is made of high-quality materials and components. It may be used indoors and outdoors due to its durability. DHT22 sensor has four pins for convenient connection to microcontrollers or development boards. DATA, VCC, GND, and NC are the pins. This simple interface makes thermostat sensor integration easy.

DHT22 sensor corrects measurements for accuracy and stability. It validates data with a checksum technique to reduce errors. Arduino, Raspberry Pi, and ESP8266-based boards like the NodeMCU support the DHT22 sensor. The sensor's broad interoperability makes it easy to integrate into your thermostat project and use these platforms' large libraries and resources. Cost-Effective: The DHT22 sensor is cheaper than other high-precision temperature and humidity sensors. DIYers and pros love its accuracy, reliability, and cost. The DHT22 temperature/humidity sensor is a reliable and precise thermostat sensor. Its simplicity, compatibility, and affordability make it a good choice for adding environmental sensing to your thermostat project.

2.4.3 MH-Z19 CO_2 sensor

Figure 2.8 MH-Z19

The well-praised MH-Z19 CO2 sensor detects and measures atmospheric CO2. Indoor air quality monitoring, ventilation control systems, and greenhouse gas monitoring use it.

The MH-Z19 CO2 sensor measures air CO2 concentration using non-dispersive infrared (NDIR). It has a gas chamber, infrared light source, and detector. The detector monitors CO2 molecule absorption of infrared light from the source as it passes through the gas chamber. The sensor calculates CO2 concentration from absorption. MH-Z19 CO2 sensor measures 0-5000 ppm or more. This range includes typical atmospheric CO2 levels in diverse situations for accurate monitoring and control. The MH-Z19 CO2 sensor measures CO2 concentrations accurately. Its precision is usually 50 ppm or 3% of the measured value. This accuracy guarantees accurate CO2 detection in your application. MH-Z19 CO2 sensor provides near-real-time readings. CO2 concentration variations are detected and responded to within seconds. MH-Z19 CO2 sensor needs regular calibration. For consistent measurements, follow the manufacturer's calibration protocols and frequency. The sensor is exposed to a known CO2 concentration and adjusted for calibration. MH-Z19 CO2 sensor communicates with microcontrollers and other devices via digital output. The UART protocol simplifies sensor integration into your project. A microcontroller can process the CO2 sensor's digital signal. MH-Z19 CO2 sensor commonly has ABC. ABC lets the sensor continually monitor the baseline CO2 content in the surroundings and adapt its measurements. This feature corrects long-term sensor drift. The low-power MH-Z19 CO2 sensor is appropriate for battery-powered applications. It uses little power, extending your monitoring system's battery life.

High-quality materials and components make the MH-Z19 CO2 sensor durable and reliable. It may be used indoors and outdoors due to its durability. The MH-Z19 CO2 sensor has a small packaging with a few pins for easy integration into your project. UART communication uses VCC, GND, TX, and RX pins. This simple interface allows sensor integration with microcontrollers and other devices. The MH-Z19 CO2 sensor works with Arduino, Raspberry Pi, and ESP8266-based boards. These platforms' broad libraries and resources enable smooth integration into your monitoring or control system. The MH-Z19 CO2 sensor has many uses. Indoor air quality monitoring systems employ it to ensure proper ventilation and healthy living or working conditions. It measures and controls CO2 levels in greenhouses for optimal plant development. In HVAC systems, the sensor controls fresh air intake and energy efficiency. The MH-Z19 CO2 sensor detects and measures CO2 levels accurately. It monitors and controls CO2 concentrations in numerous applications thanks to its NDIR technology, high accuracy, fast response time, and microcontroller compatibility.

2.4.4 DS3231 real-time clock

The DS3231 is a popular real-time clock (RTC) module used in electrical systems that need precise timekeeping. It's ideal for data logging, time-sensitive data collecting, alerts, and scheduling due to its advanced features.

DS3231 uses a temperature-compensated crystal oscillator (TCXO) for precise timekeeping. Its timekeeping accuracy is within a few seconds every month, making it suited for applications that demand accurate time synchronization. DS3231 connects with the microcontroller or other devices using the I2C (Inter-Integrated Circuit) protocol. Integration into numerous electronic systems is easy with this two-wire serial interface.

Figure 2.9 - DS3231

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Even during power interruptions, the DS3231's battery backup system keeps time. An external coin cell or supercapacitor powers the RTC and stores the time and date. DS3231 has complete timekeeping and calendar functions. Hours, minutes, seconds, days, dates, months, and years are correctly tracked. Leap year compensation and 12-hour and 24-hour time formats are supported. Two customizable alarms are on the DS3231 RTC module. These alarms can be set to trigger at certain periods, allowing the microcontroller or system to generate an interrupt or alarm signal. The DS3231's integrated temperature sensor measures the ambient temperature. Through the I2C interface, the system can monitor and adapt for temperature differences that may influence timekeeping accuracy.

1Hz to 32.768kHz, the DS3231 can generate a square wave output. Other devices use this feature as a clock signal or to signify system events. DS3231's aging compensation features adjust timekeeping accuracy over time. The oscillator's intrinsic frequency drift is taken into account to preserve timekeeping performance. The DS3231's low power consumption makes it appropriate for battery-powered applications. The normal operation uses less power, extending the system's battery life.

The microcontroller or other devices can connect to the DS3231's alarm interrupt pin. Alarms send interrupt signals to the system, allowing it to act quickly. DS3231's oscillator stop flag signals if the clock's oscillator has stopped or if timekeeping is inaccurate. This option lets the microcontroller detect and fix RTC faults. DS3231 is offered as a tiny surface-mount device or module with pin headers. It can be soldered onto a custom PCB or integrated into other electronic designs.

In conclusion, the DS3231 real-time clock's accurate timekeeping, advanced features, and easy integration make it a reliable choice for applications that demand precise timing and scheduling. Its I2C interface, battery backup system, alerts, and temperature correction make it helpful in many electronic systems and gadgets.

2.4.5 Blue graphic display 0.96" I2C OLED LCD

Figure 2.10 – 0.96" I2C OLED LCD

Blue Graphic Display 0.96" I2C OLED LCD is a compact and flexible display module that combines OLED (Organic Light-Emitting Diode) technology with a user-friendly I2C interface. This display module has many benefits that make it useful in electronic applications.

The display uses organic chemicals that generate light when an electric current is applied. OLED displays provide high contrast ratios, wide viewing angles, fast response times, and self-emitting pixels (no backlight). The 0.96-inch diagonal Blue Graphic Display 0.96" I2C OLED LCD is small. Its 128x64 to 128x32-pixel display is brilliant and vibrant despite its modest size. This displays alphanumeric characters, icons, images, and rudimentary animations. The display module has an I2C interface, commonly known as IIC or TWI. This two-wire serial communication protocol makes microcontrollers like Arduino, Raspberry Pi, and other embedded systems easier to control. I2C communication requires a few wires, simplifying wiring.

The Blue Graphic Display 0.96" I2C OLED LCD integrates easily into electronic projects. It commonly comes as a module with pre-soldered pin headers for easy breadboard or custom PCB connection. I2C's fewer pins make it easier to employ with limited GPIO (General Purpose Input/Output) resources. OLEDs have white or blue pixels on a black background. Text, graphics, and images can be rendered with fine pixel control. Sharp, high-contrast images make the monochrome display readable in various lighting conditions. OLED technology has low power consumption. OLED screens only use electricity when pixels are active, unlike LCD displays that need a backlight. The Blue Graphic Display 0.96" I2C OLED LCD is ideal for battery-powered devices and power-optimized applications due to its energy efficiency. The OLED display provides smooth, flicker-free animations and transitions. Real-time changes and dynamic content display benefit from this feature.

The display module usually has built-in font libraries and graphic support to render text in multiple sizes and styles and display custom visuals and icons. This facilitates user interface creation and screen display. OLED displays have wide viewing angles, making content visible from all angles. Multi-user apps benefit from this feature. Blue Graphic Display 0.96" I2C OLED LCD often exceeds 1000:1. The display produces deep blacks and bright whites, improving image quality and legibility. OLED displays operate at low voltage, usually 3.3V or 5V, making them compatible with many microcontrollers and development boards. The Blue Graphic Display 0.96" I2C OLED LCD is a flexible and compact display module that combines OLED technology with an I2C interface. Wearables, IoT devices, prototyping, and embedded systems benefit from their tiny size, low power consumption, excellent contrast ratio, wide viewing angles, and easy integration.

2.4.6 Transmitter 433MHz

Figure 2.11 – Transmitter 433MHz

Wireless communication modules at 433MHz are called 433MHz transmitters. Telemetry, data transmission, and remote control use it. The 433MHz transmitter is explained in full.

The 433MHz transmitter works in the Ultra High Frequency (UHF) range. Due to its good balance of range and penetration through walls and barriers, this frequency band is commonly utilized for short-range wireless communication. The transmitter sends data or control signals wirelessly. It sends information from a transmitter module to a receiver module at the same frequency using radio waves. It's excellent for remote control or data transmission without wiring. The 433MHz transmitter's wireless communication components are usually in a separate module. It has an antenna, an RF transmitter chip, and supporting electronics. Electronic projects and embedded systems can readily integrate the module.

The 433MHz transmitter's range depends on broadcast power, antenna design, environment, and interference. The range can be several hundred meters in open spaces. The range may be decreased by barriers or electromagnetic interference. The transmitter sends digital or analog data. Sensor readings, orders, and control signals can be sent via it. To reduce interference and ensure reliable transmission, data can be encoded and modulated. Modulation: The 433MHz transmitter uses numerous modulation methods to encode data onto radio waves. ASK, FSK, and OOK are common modulation methods in 433MHz systems. Data transmission is efficient and the receiver can demodulate and retrieve the original data using these modulation methods. A special communication protocol or encoding scheme is commonly used with the 433MHz transmitter. These protocols govern the structure, timing, and data format for transmitter-receiver communication. Virtual Wire, RC-Switch, and Manchester encoding are utilized with 433MHz transmitters. Successful communication requires protocol compatibility between the transmitter and receiver.

A 3.3V or 5V power supply powers the transmitter module, which uses low power. It's energy-efficient, making it suited for battery-powered applications. The 433MHz transmitter module is easy to integrate into electronic applications. It often features conventional pinouts or connections for connecting to microcontrollers, development boards, or other electrical circuits. Digital GPIO pins or serial communication interfaces like SPI or UART are common interfaces. The 433MHz transmitter has several uses. Wireless remote controllers for home automation, automobile alarms, garage door openers, and wireless security systems use it. It transmits sensor data from weather stations, wireless sensor networks, and telemetry systems. It can also be used in robotics, IoT, and hobbyist projects. The 433MHz transmitter is a wireless communication module that operates at that frequency. Remote control, telemetry, and data transmission can use to remotely transmit data or control signals.

2.4.7 Arduino Pro Mini 5V

The Arduino Pro Mini 5V is a powerful and flexible microcontroller board. Let's examine its main features: The Arduino Pro Mini 5V uses the ATmega328P microcontroller. This 16 MHz 8-bit AVR microcontroller is powerful and efficient. For applications that require fast processing and response times, it can execute instructions swiftly.

Figure 2.12 Arduino Pro Mini 5V

The Arduino Pro Mini 5V uses 5V, which is compatible with many electronic components and modules. This operating voltage simplifies complex project development by integrating sensors, actuators, displays, and communication components. The board has 14 digital I/O pins, 6 of which can create PWM signals. PWM pins offer accurate speed, intensity, and position control of motors, LEDs, and servos. 8 analog input pins allow accurate analog sensor readings. Arduino Software (IDE) can program the Arduino Pro Mini 5V. The IDE makes authoring, building, and uploading board code easy. Its extensive library of pre-built functions and examples helps beginners get started and advanced users speed up development.

The board offers several power alternatives for different projects. 5V or RAW power it. The 5V pin requires a regulated 5V power supply. The RAW pin also accepts unregulated voltage between 6V and 12V, which is controlled onboard to produce a constant 5V supply. The Arduino Pro Mini 5V supports UART, SPI, and I2C. These connections allow the board to seamlessly exchange data and integrate into complicated systems with sensors, displays, wireless modules, and other microcontrollers. The Arduino Pro Mini 5V is tiny. It is much smaller than normal Arduino boards at 0.7 x 1.3 inches (17.78 x 33.02 mm). Its modest size makes it excellent for little projects. It fits into custom PCBs or breadboards for quick prototyping. Arduino Pro Mini 5V is intended for power efficiency. It uses power-saving methods and sleep modes to conserve battery life. Wearables, remote sensing systems, and environmental monitoring applications benefit from this capability. Arduino Pro Mini 5V is part of the large Arduino ecosystem of enthusiasts, developers, and specialists. This ecosystem offers free libraries, tutorials, and coding examples. The active community supports and collaborates, making it easy to troubleshoot, learn, and build on current projects.

The Arduino Pro Mini 5V is used in many projects. Robotics, home automation, IoT, data logging, prototyping, and more can use its tiny size, low power consumption, and wide feature set. It adapts to diverse project requirements and scales from basic prototypes to complex systems. The Arduino Pro Mini 5V is a powerful microcontroller board with a compact form size, abundant I/O, and Arduino ecosystem compatibility. This board gives beginners and professional developers a solid platform for building electronic projects, allowing you to explore your imagination and transform your ideas into reality.

2.4.8 Receiver 433MHz

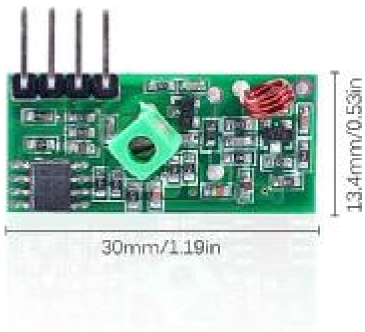

Figure 2.14 – Receiver 433MHz

Wireless communication systems need 433MHz receiver modules. I will explain it functions and features.

The receiver runs at 433MHz, a UHF frequency. Short-range wireless communication uses this frequency band, which balances signal range and data transfer rate. The 433MHz receiver module receives RF signals from compatible transmitters. It has a 433MHz-tuned RF receiver circuit. The module's circuitry is tailored to catch and demodulate signals at this frequency, ensuring data receipt. The receiver module is crucial in radio wave-based wireless communication systems. It allows short-range wireless data transfer when coupled with a transmitter. Remote control systems, wireless sensors, weather stations, home automation, and more can use it. The receiver module demodulates RF signals to extract data. ASK or FSK modulation is typical. The receiver's demodulation circuitry reconstructs the data from these modulation methods.

The receiver module can detect and interpret weak RF signals. High-sensitivity receivers can detect signals at minimal power, improving wireless communication

system range and performance. The receiver's effective range relies on transmitter power, line-of-sight conditions, and impediments or interference. Signal reception relies on the receiver module's integrated or removable antenna. The antenna receives and sends RF signals to the receiver electronics. The antenna may be wire, printed on the PCB, or a connector for an external antenna, depending on the module. 433MHz receiver module works flawlessly with 433MHz transmitters. This compatibility allows the receiver to accurately receive and interpret signals from the connected transmitter. Communication requires that the receiver and transmitter use the same frequency and modulation techniques. The receiver module normally outputs a digital signal indicating data reception. For processing, Arduino or Raspberry Pi microcontrollers can interface with this output signal. The module may have additional control pins or configuration options to modify its behavior and performance. The receiver module requires 3.3V to 5V. For battery-powered applications, it uses little power. For reliable operation, the power supply must be stable and meet module requirements.

433MHz receiver modules are widely used. Garage door openers, remote keyless entry systems, and home automation devices use it. Wireless sensor networks, weather monitoring systems, data loggers, and other short-range wireless communication applications use it. In 433MHz wireless communication systems, the receiver module is essential. It receives and demodulates RF signals from compatible transmitters, enabling short-range wireless data transfer. Its versatility and interoperability make it a crucial component for many wireless communication applications.

2.4.9 2-channel relay

Low-voltage signals control two electrical circuits with a 2-channel relay. It controls gadget power. Let's examine a 2-channel relay's capabilities.

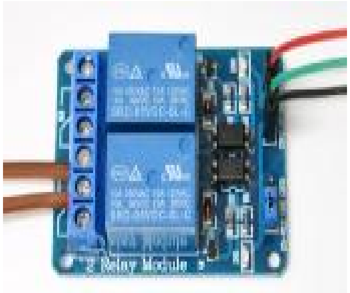

Figure 2.15- 2-channel relay

A relay has an electromagnetic coil, one or more sets of contacts (poles), and a device to control their movement. The coil provides a magnetic field that attracts or releases the contacts, forming or breaking the circuit. 2-channel relay has two separate channels or poles. Each channel controls a circuit or device. Using a relay module, you can control numerous devices concurrently or separately. The relay contacts' switching capacity limits its voltage and current. Make sure the relay's specs meet or surpass the devices you're controlling. Voltage (V) and current (A) values specify switching capacity. NO and NC relay interactions are possible. The resting state has NO contacts open and NC contacts closed. The relay opens the NC contacts and closes the NO contacts. This option lets you choose generally open or normally closed operations dependent on your application. Low-voltage input signals trigger the relay. Arduino, Raspberry Pi, or other control circuits can give it. The relay coil energizes when the control signal is applied, switching the contacts.

Relays isolate control circuitry from switched circuits. This isolation protects the low-voltage control side from the high-voltage side. It protects delicate control components from voltage spikes. Home automation, industrial control systems, robotics, automobile electronics, and more use 2-channel relays. Remotely control lights, fans, motors, appliances, and more. Its many channels allow complicated control systems and simultaneous device operation. The relay module usually has terminal blocks or headers for wire connections. Each channel has separate terminals for NO, NC, and common connections. The relay's pinout and labeling must be followed for good operation.

Choosing a relay module that matches the control signal voltage and current is very important. Making sure that the relay's control voltage fits the control circuitry and that its switching capacity can accommodate the device’s current. Working with relays, especially high voltages, requires safety precautions. Preventing electrical risks requires proper insulation, grounding, and electrical safety. A 2-channel relay allows low-voltage control of two electrical circuits. It allows independent or simultaneous device switching, flexibility, and isolation. A 2-channel relay simplifies electrical control and automation in home automation, industrial control, and other applications.

2.4.10 K-PM01 adaptor

The small HLK-PM01 power module or adapter converts AC voltage to DC voltage to power electronic devices. The HLK-PM01 converts 100-240V AC wall outlet voltage to regulated DC voltage for electronic circuits. It's employed in applications that need consistent electricity. The HLK-PM01 adapter efficiently converts AC voltage to DC voltage using a high-frequency switching power supply. This conversion uses a transformer, rectifier circuitry, and voltage regulation. The HLK-PM01's tiny size is an advantage. For space-constrained applications or portability, it is tiny and lightweight.

Figure 2.16- K-PM01 adaptor

HLK-PM01 adapter handles 100V to 240V AC input voltages, making it compatible with global power systems. Model and application determine the output voltage. 3.3V, 5V, 9V, and 12V DC outputs are common. HLK-PM01 adapter offers great efficiency and consistent voltage regulation. Capacitors, inductors, and integrated circuits reduce power loss, regulate the output voltage, and guard against voltage spikes and fluctuations. The HLK-PM01 adapter is safe and reliable. It protects electronics from electrical failures via overvoltage, overcurrent, and short-circuit protection. The HLK-PM01 adapter normally has mounting holes or tabs to fasten it to a surface or enclosure. It's easy to install in electronic projects. Home automation systems, industrial control equipment, IoT devices, smart appliances, robots, and low-power embedded systems use the HLK-PM01 adaptor. It powers microcontrollers, sensors, displays, and other electronics reliably. The HLK-PM01 adapter is usually made to meet safety requirements like UL or CE certification. Users may rest well knowing the adapter satisfies safety and performance standards.

The HLK-PM01 adapter usually contains screw terminals or pins to securely link input and output wires. For proper performance and device protection, follow the manufacturer's polarity and wiring guidelines. The compact and efficient HLK-PM01 adapter converts AC voltage to regulated DC voltage. It powers numerous electrical devices and systems with its tiny form size, safety features, and wide input voltage range.

2.5 Justification of the choice of software of the WIFI thermostat

The Arduino IDE lets you write, compile, and upload code to Arduino microcontroller boards.

The Arduino IDE is a programming environment for Arduino boards. It simplifies Arduino code creation and uploading with a nice UI and tools. Download the Arduino IDE for free at https://www.arduino.cc/. Windows, macOS, and Linux support it. The IDE lets users write and compile Arduino code after installation. The Arduino IDE has a code editor for writing and editing sketches. The editor helps write good code with syntax highlighting, automatic indentation, and code suggestions. Arduino development uses C/C++. Arduino projects can use the IDE's pre-written code examples and libraries. These examples include LED control, sensor reading, and device communication. Beginners can start fast and use the code library for more complicated projects. The Arduino IDE's compiler converts code into Arduino board instructions. A USB cable can upload compiled code to the board. The IDE transfers the code to the board correctly.

Arduino supports many microcontroller boards with different specifications and capabilities. A board manager in the IDE lets users choose their Arduino board. It provides drivers and configurations for IDE-board communication. The Arduino IDE has a serial monitor for serial port communication with the Arduino board. This helps debug and monitor code behaviour during runtime. The serial monitor displays Arduino board data and lets users submit commands or messages to it. The Arduino IDE support these. Arduino libraries add functionality and features. The IDE's library manager makes including libraries in drawings easy. Arduino has a huge and active developer and enthusiast community. The Arduino IDE has forums, documentation, and tutorials where users may get help, exchange projects, and cooperate. Arduino's community provides information and support for all skill levels. The Arduino IDE source code can be modified and improved. Developers may improve it, correct issues, and customize it.

In conclusion, the Arduino IDE is a powerful and easy-to-use Arduino programming software. It simplifies development with tools, a code editor, libraries, and a serial monitor. Beginners and professional developers use the Arduino IDE to create interactive projects and prototypes due to its large community support and open-source nature.

2.6 Computer system flowchart for WIFI thermostat

This is how the flowchart works. Firstly, I selected the thermostat's features and functions. Wi-Fi connectivity, smartphone management, temperature, and humidity detection, CO_2 monitoring, scheduling, energy-saving alternatives, and other desirable features should be considered. Make a list of project components and tools. I chose a board like Arduino or ESP8266 that supports Wi-Fi and has enough computing capability.

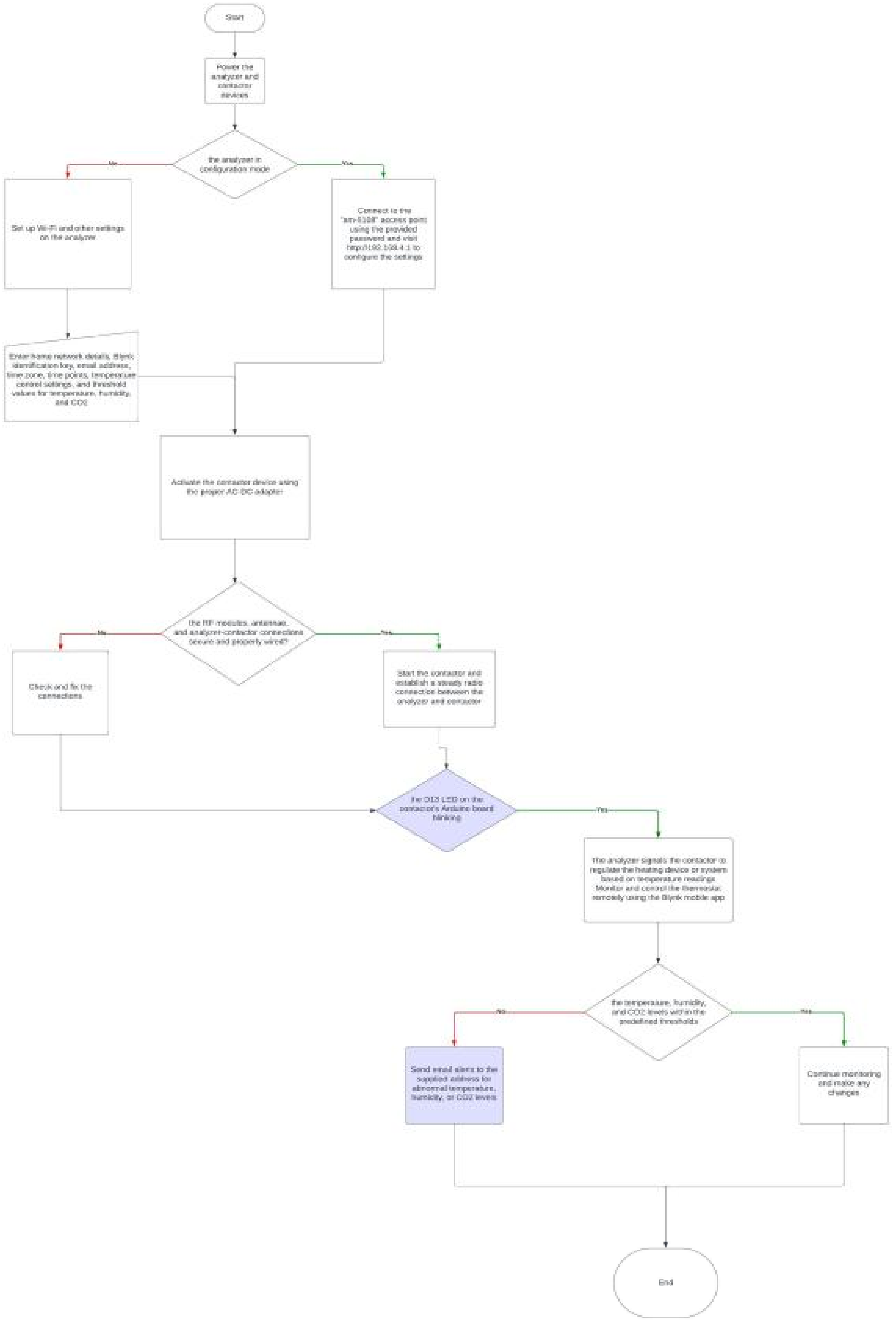

Figure 2.17- The flowchart

I chose a dependable sensor the DHT22 for precise readings in the specified temperature and humidity range. I used MH-Z16 to monitor CO2 levels accurately. I chose DS3231 enables precise timekeeping for scheduling functions. I chose an OLED display module with at least 128x64 pixels to clearly display temperature, humidity, CO_2 levels, and other information. For wireless thermostat connection I used a dependable RF transmitter and receiver pair. Control furnaces and HVAC systems using the right relay modules. I chose an AC/DC adapter for the thermostat.

I started by attaching the OLED display module, real-time clock module, and temperature and humidity sensor to the Wi-Fi-enabled microcontroller board. Connect the CO_2 sensor to the microcontroller. To ensure power supply and signal compatibility, use voltage regulators and logic level converters as needed. Implement the appropriate circuitry to enable microcontroller board-to-component communication. The microcontroller should read data from the temperature, humidity, and CO_2 sensors and show it on the OLED display.

Using the real-time clock module, synchronize the microcontroller to an internet time server. Create firmware for the microcontroller to regulate the thermostat depending on preset settings including target temperature ranges, humidity thresholds, and CO_2 level limitations.

Implement scheduling, energy-saving options, and smartphone remote control. Consider sending an email or push notifications if temperature, humidity, or CO_2 levels exceed the criteria. Calibrate the sensors for accurate measurements and fine-tune the firmware for reliable and precise functioning.

I chose an Arduino Pro Mini for the contactor unit. To communicate wirelessly with the analyser unit, connect the RF receiver module to the microcontroller board. Make sure the relay modules are properly wired to the microcontroller board and compatible with the heating equipment. I created firmware for the contactor unit to receive signals from the analyser unit through the RF receiver module and control the relays. Based on sensor readings and specified thresholds, automate humidification, forced ventilation, and air conditioning. Test the control unit and make sure it communicates with the analyser. I chose cases or enclosures for the analyser and contactor units based on size, material, and aesthetics. Make sure the cases have enough airflow for reliable temperature and humidity measurements. External interfaces like buttons, the OLED display, and power connections need access points. Consider mounting choices, cable management, and user-friendly design while choosing cases. Power up the analyser and put it in offline or setup mode. Use a web interface, smartphone app, or thermostat buttons and display to set Wi-Fi and other options. Link the analyser to the internet and your home network. Set temperature, humidity, CO2, and schedule choices. Enable email and push alerts if desired, configuring credentials and SMTP server details. Turn on the contactor unit and make sure it connects to the analyser unit wirelessly. Adjusting temperature settings, watching heating devices, and checking sensor data will test the thermostat's operation. Install the thermostat in a location that optimizes sensor placement, wireless connectivity, and accessibility.

CHAPTER 3 PRACTICAL PART

3.1 Problems with modern thermostat

Due to their ease and flexibility, wireless room thermostats have become popular. However, these drawbacks can reduce its efficacy.

Most wireless room thermostats include one internal temperature sensor. This sensor measures ambient temperature near the thermostat. This method may not precisely approximate room temperature. Room layout, sunlight exposure, and localized heat sources can affect temperature. Thus, a single sensor may give inaccurate temperature readings and poor comfort control. Wireless room thermostats cannot zone a building for separate temperature control. This constraint might cause unequal heating and cooling in multi-room homes. Different regions may cause discomfort and energy waste.

Zoning allows for zone-specific temperature management, maximizing comfort and energy economy. Wireless room thermostats can manage HVAC systems, however, only certain models or brands are compatible. This may require system updates or replacements. Compatibility concerns might limit control options, prohibiting users from using advanced HVAC functions or enhancing system efficiency.

Many commercial wireless room thermostats cannot learn user preferences or adapt to changing trends. These thermostats usually follow pre-set schedules or manual adjustments without considering occupancy patterns, daily routines, or seasonal fluctuations. Thus, residents may have to manually adjust the temperature, which wastes energy and is inconvenient. Intelligent learning algorithms and adaptive features can automatically modify temperature settings based on human behavior and ambient factors to increase comfort and energy economy.

Many wireless room thermostats lack remote control and communication. Some offer minimal Wi-Fi access, but only for smartphone-based temperature adjustments.

Energy monitoring, air quality alarms, and smart home ecosystem integration may be missing.

Real-time information, remote monitoring, and control are essential for enhancing comfort and energy management, especially when users are away from home. Limited connectivity prevents this. Installing and installing wireless room thermostats requires technical expertise or professional help. Installing a model may require cabling, connection with a central control unit, or customizing settings through sophisticated menus. Complexity may prevent customers from using these thermostats or lead to faulty installation and poor performance. Adoption and user satisfaction depend on easy installation and configuration.

Commercially available wireless room thermostats provide basic energy usages information like historical statistics or energy-saving advice. However, information and analysis are limited. Real-time consumption feedback, cost estimation, and breakdowns by HVAC equipment or time periods are rarely available. Energy monitoring helps customers make informed decisions, find energy-saving options, and track energy conservation efforts. Developers can improve advanced wireless room thermostats by knowing their limits.

Therefore, a more advanced and convenient thermostat can meet users' evolving comfort, energy efficiency, and control needs by incorporating more accurate temperature sensing, zoning capabilities, improved compatibility with HVAC systems, intelligent learning algorithms, comprehensive connectivity options, user-friendly installation procedures, and detailed energy monitoring features.

3.2 Powering of the Wi-Fi Thermostat

First, I power the AC/DC adaptor. This powers the analyser. I secure the AC/DC adapter's power cord to the analyser's power input. I wait 3 minutes after connecting the power. The thermostat goes offline at this time, preparing it for setup. After three minutes, the analyser displays air parameters. The first line displays the current environmental temperature. The second line shows atmospheric humidity. Finally, the third line shows the thermostat's mode: offline, online, or OffBlynk. If any air parameters surpass threshold values, it may inform me to alter them.I restart the analyser's AC/DC adapter to configure the thermostat. The analyser restarts with a familiar message. My phone or laptop searches for networks. The password connects me to "am-5108" in the list of available networks. I enter "http://192.168.4.1" on my device's web browser after connecting to the "am-5108" access point. The thermostat's web interface appears. The web interface has many thermostat configuration possibilities. I find the thermostat settings form online. This form lets me connect the thermostat to my home Wi-Fi network for remote control. For enhanced functionality and notifications, I can enter a Blynk identification key and email address. I also customize time zone, time points, and temperature thresholds. I configured the temperature control software to my schedule and temperature. This lets the thermostat automatically adjust to my preferences. After making the appropriate changes, I clicked "Save" on the web interface to save the settings. This starts my analyser's Wi-Fi connection. After connecting, the thermostat works according to my settings. I tightened and aligned the AC/DC adapter and contactor to regulate the heating device or system. Next, I connected the heating device or heating system electronics to the contactor's open relay contacts, double-checking for functioning and safety. The Arduino board's blinking D13 LED verifies the analyser-contactor radio connection. This LED indicates analyser-contactor connectivity. The relay module's LED lights up when the analyser tells the contactor to switch on the heater or heating system.

The Blynk smartphone app improves thermostat control and monitoring. The Blynk app on my phone opens up remote thermostat control options. The app lets me customize visuals, receive notifications, and precisely manage the thermostat. After launching the app, I customized it. This may involve choosing widgets, modifying the interface, and setting up temperature and humidity warnings. After setup, I link Blynk to the thermostat. This secure link lets me access real-time thermostat data and control it from my smartphone. I can easily monitor temperature, humidity, CO2 level, and other data with Blynk. The app graphs measured and thermostated temperatures. The app lets me establish temperature targets, alter parameters, and track heating system performance. I connect the heating device or electronics if the contactor works. I took safety precautions to install it safely. I carefully connected the heating unit, checking the wiring and electrical factors. I checked the wire connecting the heating device's cross-section using the copper wire indicator (5 A / mm2) to guarantee optimal performance and safety. This makes sure the wiring can manage the electrical load. After setup, I tested and optimized the system. I turned on the AC/DC adaptor and carefully watched the screen. I checked that the temperature, humidity, and CO_2 concentration values match the environment. Next, I used the Blynk app on my phone to control the thermostat and monitor the heating system. I made sure the contactor reacts to commands and switches the heating device on and off. This confirms that the thermostat is controlling the heating system and maintaining the proper temperature. During testing, I monitored the room temperature and adjusted the thermostat to achieve comfort. Based on my tastes and daily habits, I fine-tuned the thermostat temperature management program. I also changed temperature and humidity thresholds for best performance and energy efficiency. I monitored the thermostat's operation. I monitored the heating device's response and temperature consistency. I can reconfigure the thermostat and contactor if problems emerge or if I want to make more modifications. I can set up and turn on the thermostat by following these extensive instructions and learning its functions. This ensures heating system connectivity, accuracy, and control. The thermostat gives me remote access, perfect temperature control, and energy savings.

3.3 Placement of DHT22

Accurate and consistent measurements depend on the location and positioning of the DHT22 temperature and humidity sensor. Consider these factors when placing the sensor: Maintenance and calibration require easy sensor access. Make it accessible without disassembling the system.

Place the sensor in an area that matches the temperature and humidity you wish to observe. It should be placed centrally in a room to monitor its indoor climate. It captures the average temperature and humidity without localized fluctuations. External variables might cause measurement errors. Avoid direct sunshine, radiators, and electrical appliances. Sunlight and heat can raise temperature measurements. Avoid positioning the sensor in airflow from fans or vents, which might impact humidity reading. Consider sensor mounting height. It accurately measures temperature and humidity when mounted at the right height. If you're monitoring room conditions, placing the sensor at chest height will better represent inhabitants' temperature and humidity. The DHT22 sensor is sensitive to moisture, so it must be protected from liquids. Avoid placing it in humid, water-leaking, or condensation-prone regions. Moisture can cause sensor errors. Protect the sensor from moisture by enclosing it. Your application may require frequent DHT22 sensor calibration. Calibration should be straightforward to access. Consider aspects such as calibration equipment availability, sensor calibration adjustment points, and environmental change recalibration.

Test and validate sensor placement. This entails comparing DHT22 sensor results with other valid temperature and humidity benchmarks in the same environment. This validation ensures precise and consistent measurements at the designated location. Consider these parameters to find the best location for the DHT22 temperature and humidity sensor for your monitoring needs. Maintaining the sensor will ensure accurate temperature and humidity data over time.

3.4 Alternate for DHT22

Other temperature and humidity sensors exist besides the DHT22. Each option has its own benefits and applications. These alternatives: BME280 sensors are popular. It accurately measures temperature, humidity, and barometric pressure. I like the BME280's multi-parameter sensor. This simplifies system design because I don't require sensors for each parameter. I can integrate the BME280 into my projects through I2C or SPI. I don't have to calibrate the BME280's digital output either. Weather monitoring, indoor climate management, and environmental sensing use it. SHT31 is another option. It accurately measures temperature and humidity. The SHT31 is versatile due to its large measuring range for both parameters. When using battery-powered devices, the low power consumption is a big plus. Microcontrollers support SHT31's I2C interface.

The SHT31, like the BME280, provides calibrated digital output for reliable measurements without calibration. HVAC, weather, and industrial automation use it. AM2302 is a simple DHT22 replacement. It measures temperature and humidity like the DHT22. Hobbyists and beginners like its accuracy and simplicity. The AM2302 is cost-effective and widely available for temperature and humidity sensor applications. HDC1080 sensors are accurate and low-power. Its wide temperature and humidity range compensates for environmental changes. This adjustment ensures accurate measurements under difficult settings. For real-time monitoring and control, the HDC1080 responds quickly. It communicates over I2C like the others, making integration into my projects easier. HDC1080's calibrated digital output removes calibration. I evaluate the accuracy, measurement range, power consumption, interface compatibility, and cost while choosing a DHT22 replacement. I consider application and environment. These variables help me choose the sensor that meets my needs. My options let me choose the best sensor for my project.

3.5 Power Supply for Analyser

I intended to give the analyser's components and circuits a consistent and reliable power supply. I designed a robust system with many voltage regulation and protection stages to achieve this. A dedicated power supply unit powers the arrangement. This unit powers the analyser and accepts AC input voltage from a wall outlet. Transformers, rectifiers, and smoothing capacitors convert and filter AC voltage into DC voltage in the power supply unit. I used linear and switching voltage control to regulate the voltage. Linear voltage regulators start voltage regulation. This regulator converts unregulated DC voltage from the power supply unit to a particular output voltage. The linear voltage regulator maintains output voltage regardless of input voltage or load variations. Dissipating surplus energy as heat can reduce power efficiency. However, the linear regulator excels in voltage regulation and low output noise, making it perfect for delicate analog circuits or components that need consistent voltage levels. Switching regulators boost power supply efficiency. High-frequency switching regulators efficiently convert and regulate voltage. These regulators produce larger output currents while reducing power dissipation and improving power efficiency. Switching regulators improve energy efficiency, especially for high-voltage components and modules. I use filtering capacitors at the input and output stages of voltage regulators to maintain voltage stability.

These capacitors smooth out the regulated voltage's remaining fluctuations and noise, providing a clean and reliable power supply for the analyser's components. To maximize high-frequency noise filtering, I choose capacitors with optimal capacitance values and low equivalent series resistance (ESR). Power rails and dedicated connections distribute controlled voltage to analyser sections and components. Power rails conduct the regulated voltage to circuits and components. Power rails eliminate voltage dips and provide consistent voltage to each component. Voltage protections prevent component and circuit damage. Fuse, TVS, and over-voltage protection circuits are used. The power supply circuit has strategically positioned fuses to protect components from high currents. TVS diodes prevent voltage spikes and transients caused by lightning strikes or power surges. Over-voltage protection circuits monitor voltage levels and automatically shut off power to protect the analyser.

In conclusion, the analyser's power supply and voltage regulation are carefully engineered to offer reliable and stable power. I use linear voltage regulators, switching regulators, filtering capacitors, and protective measures to provide power efficiently, reduce output noise, and safeguard against voltage variations and transients. This powerful power supply system helps the analyser measure, control, and analyze signals accurately.

3.6 Power Supply to Contactor Device

To ensure reliable and effective contactor device power supply operation, I considered numerous elements. First and foremost, I chose a high-quality power adapter or DC power supply that meets contactor device standards. The Arduino Pro Mini, the contactor device's brain, needs a solid 5V to 12V power supply. Surge protectors and voltage regulators protect the contactor device and its components from power surges and voltage fluctuations. These devices protect contactor device electronics from voltage spikes and drops. Fuses safeguard the contactor device and heating system against excessive current flow. Safe and reliable contactor device operation requires proper grounding. I carefully connected the power supply grounding wire to the contactor device ground terminal.

This prevents electrical shocks and equipment damage by dissipating stray electrical charges. I secure the contactor device’s electrical safety by grounding properly. A 2-channel relay module connects the contactor device to the heating system. The relay module lets the contactor device turn the heating system's electrical circuit on and off. The relay module is wired to the heating system's power supply and control input terminals. I used high-quality heating system-compatible cables and connections for a secure and stable connection. Neat wiring prevents loose connections and short circuits. To organize and secure the wiring, I used cable ties and conduits. I separated the contactor device's low-voltage control signals from the heating system's high-voltage power circuits to avoid interference. Separate wire lines and insulation do this. I reduce the possibility of electrical noise or cross-talk affecting the contactor device or heating system safety by doing so.

In conclusion, the contractor device's power supply requires a stable power source, surge protectors, voltage regulators, and grounding for safe and continuous functioning. A 2-channel relay module safely connects the heating system. I constructed a solid power supply arrangement and a secure link to operate and regulate the heating system based on received signals and measured air parameters, ensuring optimal comfort and energy efficiency in the area.

3.7 Code for contractor

Using the code in appendix A.1. My Arduino sketch started with the RCSwitch library. This library offers transmitter-based wireless communication functions. The library came from https://github.com/sui77/rc-switch.

```
        //co2
> Cmax
      if(value == B11111101) digitalWrite(5, LOW);
      else
if (value == B00000010) digitalWrite(5, HIGH);

          //h < Hmin

      if(value == B11111011) digitalWrite(6, LOW);
      else if (value ==
B00000100) digitalWrite(6, HIGH);

         //t > Tmax
      if(value
== B11110111)digitalWrite(3, LOW);
      else if (value == B00001000) digitalWrite(3,
HIGH);
```

Next, I created a mySwitch RCSwitch instance. This will interact with the wireless transmitter. I set different output pin modes in the setup() code, which runs once when the Arduino board is powered on or reset. I made pins 13, 3, 4, 5, and 6 outputs. These pins control Arduino-connected devices. I set pin modes and initialized pins 3, 4, 5, 6, and 13. Pins 3 and 4 were HIGH, while pins 5, 6, and 13 were LOW. This ensures that these pins start in the right condition for the linked devices.

MySwitch.enableReceive(0) enabled receiving on receiver pin 0. The Arduino receives wireless transmitter signals on pin 0. After setup(), I use mySwitch.available() to check for incoming signals in loop(). MySwitch retrieves the signal value.getReceivedValue() to the value variable. To determine the desired actions, I compare the value to binary patterns. These patterns indicate conditions or commands to execute.digitalWrite(4, LOW) sets pin 4 to LOW for B11111110.

This action may indicate a low temperature. If the value is B11111101, I set pin 5 to LOW to indicate a CO_2 threshold violation. If the value is B11111011, I set pin 6 to LOW, indicating a humidity level below the minimal threshold. If the value is

B11110111, I set pin 3 to LOW, indicating a temperature above the maximum threshold. Pin 13 is also an indication LED. If B10101010 is received, I put pin 13 to HIGH, indicating a transmitter connection. The transmitter sends this code without conditions.

Finally, mySwitch reset the received value status.resetAvailable(). Preparing the receiver for the next signal. This code receives transmitter signals using the RCSwitch library. It regulates Arduino board output pins based on received values. These pins link contactors, thermostats, and LED indicators. The code automates and controls room gadgets by monitoring and responding to conditions.

3.8 Wi-Fi connection

I measure temperature. I monitor room temperature with a DHT22 sensor. I transfer this temperature data to the Blynk app, which displays the real-time temperature on your smartphone. This lets you monitor room temperature and keep it comfortable. I can also automate temperature management using the Blynk app to set the appropriate temperature for different time ranges.

I also measure humidity (V2). A humidity sensor (DHT22) in my body senses atmospheric moisture. The Blynk app displays V2 humidity data as a percentage on your smartphone. This tool lets you monitor your room's humidity and change it according to your preferences or standards to keep it pleasant. CO2 Content (Variable: V3): My air quality monitor measures room CO2. V3 is essential for air quality. I send Blynk app data from my CO2 sensor (MH-Z16). You can detect poor ventilation by monitoring CO2 levels on your smartphone. To maintain a healthy and comfortable environment, open windows or activate ventilation systems. Control Temperature (Variable: V4): Use the Blynk app to set the appropriate temperature for specified time ranges for comfort and energy economy. Control temperature (V4) lets you set temperatures based on your daily schedule. For instance, you may prefer a higher temperature during the day for cosiness, but a little lower temperature at night for better sleep. You may easily input these temperature settings on the Blynk app, and I will adjust the temperature throughout the day to maintain your comfort level. Blynk integration provides you with real-time temperature, humidity, and CO2 levels and schedule-based temperature control. You can optimize energy use and create a comfortable, healthy interior environment.

```
$EMAIL=0;
$TEMPER=0;
$vlaga=0;
$carbon=0;
$device=0;
$EMAIL=$_GET["mymail"];
$device=$_GET["ID"];
echo  $EMAIL;
$TEMPER=$_GET["t"];
$vlaga=$_GET["h"];
$carbon=$_GET["co2"];
$mdate  = date("H:i d.m.y");
echo <<<END
<p>Temperature:  $TEMPER °C<p>
<p>Humidity:  $vlaga %<p>
<p>Carbon dioxide content:  $carbon ppm<p>
<p>--------------------<p>
<p>Meteostation:  $device<p>
END;
```

Using the code in appendix A.2. First, the PHP code is essential to my Wi-Fi programmable room thermostat with an air quality monitor. The backend software processes thermostat data and sends email notifications based on conditions. The script declares and initializes variables before running. $EMAIL, $TEMPER, $vlaga, $carbon, and $device. They hold thermostats and email data. The $_GET superglobal extracts HTTP GET parameters as the script runs. I can retrieve URL-sent data. This code assigns the mymail parameter value to the $EMAIL variable and the ID parameter value to the $device variable. Personalizing email messages and identifying the thermostat device require these parameters.

Next, the code sets $TEMPER, $vlaga, and $carbon to their HTTP GET arguments (t, h, and co2). The thermostat's temperature, humidity, and carbon dioxide content indicate the monitored space's air quality. The code uses date() to get the current time and date and stores it in $mdate for context. This timestamp helps users identify air quality anomalies and locate readings.

Next, echo statements and HTML markup display the temperature, humidity, and carbon dioxide content readings. Real-time air quality monitoring and visualization require this output. The script also adds the device identifier to the output so I can distinguish between several thermostats. Additionally, the code outputs the current date and time. This timestamp gives me exact reading timings. Email notifications are this code's most important feature. It sends air-quality emails using mail(). The email's subject includes the thermostat's identity and version number. The email summarizes atmospheric factors including temperature, humidity, and carbon dioxide. The email urges further analysis if any of these parameters surpass the limit levels. The email ends with a timestamp to contextualize the facts. This PHP code processes data provides real-time monitoring, and sends email notifications for abnormal air quality situations, making my Wi-Fi thermostat work. It alerts me to any deviations from the proper settings so I can maintain a comfortable and healthy living environment.

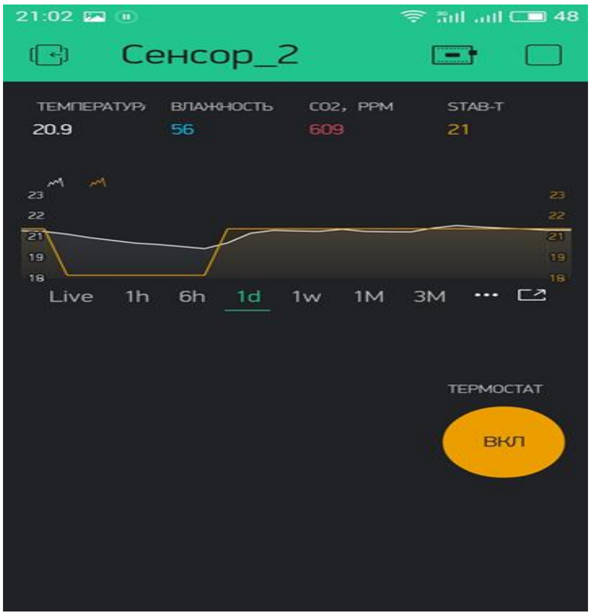

Figure 3.1- Blynk App

3.9 System Testing

A thermostat must reliably evaluate temperature, humidity, and CO_2 levels and efficiently manage the environment when tested. I'm going to demonstrate to you my deep thermostat testing processes and circumstances. I placed the thermostat in a temperature-controlled chamber to test its accuracy. I can compare this chamber's temperature to the thermostat's. I set the chamber temperature to 25°C and let the thermostat stable. I compare the thermostat's temperature to the chamber's during stabilization. I can test the thermostat's accuracy at different temperatures by repeating this approach. To ensure long-term temperature stability, I tested the thermostat. I tested the thermostat's humidity measurement accuracy using identical methods. A humidity chamber houses the thermostat. This chamber lets me set humidity to 50% relative humidity and steady the thermostat. I compared the thermostat's humidity reading to the chamber's humidity during stabilization. This approach lets me test the thermostat's accuracy at various humidity levels. Long-term stability testing ensures constant humidity readings.

I use a professional-grade CO_2 analyser to test the thermostat's air quality monitor's CO_2 measurement accuracy. For reliable CO_2 readings, the thermostat and CO_2 analyser are in the same room with sufficient ventilation. After the room stabilizes, I compare the thermostat's CO_2 reading to the reference devices. I can test the thermostat's air quality monitor under varied CO_2 concentrations by repeating this method. This ensures that the thermostat accurately reports CO_2 levels. Using the Blynk app, I established multiple temperature set-points for different time ranges to test the thermostat's control. I check the thermostat's temperature readings to ensure it reaches and maintains the programmed temperature. I see how the thermostat reacts to temperature set-point adjustments during testing. The thermostat must adjust to keep the desired temperature within a suitable zone. I tested the thermostat's response time by changing the temperature suddenly.

In addition to testing, the thermostat's operating circumstances are important. I install the thermostat away from direct heat sources, drafts, and obstructions to ensure accurate readings. To verify thermostat functionality throughout testing, I maintain a constant power supply. Test the thermostat in different seasons and climates. This assesses its performance in various scenarios and verifies its reliability under real-world usage conditions. I may comprehensively analyze the thermostat's accuracy, dependability, and control capabilities by carefully following these testing techniques and considering the testing conditions. This thorough testing ensures the thermostat satisfies standards and controls temperature, humidity, and air quality in the specified area.

3.10 Future Improvement

I am writing on how I can make improvements to the thermostat. More improvements will provide users with a really intelligent and personalized experience. Possible enhancements: Mobile App Integration: I want my own user-friendly thermostat app. This software helps users simply change temperature settings, access advanced functionality, and remotely monitor the system. Voice control and seamless integration with Apple Home-kit, Google Assistant, and Amazon Alexa are also feasible. I want algorithms to learn user preferences and change temperature settings. User behaviour, occupancy patterns, and ambient conditions determine temperature optimization for user comfort and energy economy. I'll learn and predict temperature changes for personalized comfort. I need advanced air quality monitoring. PM and VOC sensors would continuously monitor indoor air quality. I'll purify users' air. If indoor air quality drops, I can automatically adjust ventilation settings or inform consumers.

I could adjust the temperature when residents arrived or left. I could pre-activate heating or cooling systems by tracking people’s smartphones or wearable gadgets' GPS signals. Geofencing would allow users to create virtual boundaries around their home and automatically adjust temperature settings based on their preferences, saving energy while the home is vacant. Users need energy usage data. I may report energy usage, including heating and cooling cycles, via the mobile app or web dashboard. This helps users understand their energy usage, save, and obtain customized energy conservation suggestions.

I want more adjustable scheduling. For comfort and energy savings, users should be able to choose numerous temperature settings throughout the day or week. Customers might put thermostat in an energy-saving vacation mode to keep the house comfortable. I wish to work with additional house IoT and smart sensors. I can control room temperature with motion or occupancy sensors. Smart window blinds or shades would allow me to adjust to environmental conditions like sunlight or temperature, optimizing temperature control and reducing reliance on heating and cooling systems when natural lighting or insulation may provide comfort. Energy, system maintenance, and comfort optimization require extensive data analyses and reports. I record temperature trends, energy use, and indoor air quality using the mobile app or web dashboard. Users can compare energy consumption over time and get energy-saving advice.

I understand the need of keeping up with new features and improvements. Over-the-air firmware updates will give me the latest features, bug fixes, and security patches. Notifications will automatically update my program. Remote troubleshooting is also available. The mobile app or online interface lets users troubleshoot, receive step-by-step instructions, and even fix tiny issues remotely, saving time and providing easy help. Upgrades will make me a smart, energy-efficient thermostat that increases air quality, comfort, and home integration. Thermostat technology's ability to make living more sustainable and convenient using cutting-edge technologies and consumer demands intrigues me.

A Wi-Fi programmable room thermostat with an exterior temperature sensor would improve comfort, energy efficiency, and performance. Let's examine how an external temperature sensor improves thermostat functionality: The thermostat's exterior temperature sensor provides accurate and real-time data. This data helps comprehend indoor and outdoor climate conditions and better control heating and cooling systems. With real-time exterior temperature data, the thermostat can dynamically adjust indoor temperatures for optimal comfort. In colder weather, the thermostat can predict the exterior temperature drop and adjust the heating system to keep the house warm. This adaptive control feature reduces energy consumption by matching interior conditions to the weather. An outdoor temperature sensor lets the thermostat change the internal temperature based on outside conditions. The thermostat can intelligently reduce heating or cooling output in mild conditions, conserving electricity. This feature is especially useful during transitional seasons when the indoor temperature may need minor adjustments to match outdoor conditions. Weather-Responsive Programming: The thermostat uses weather data or forecasts to program. This feature lets the thermostat automatically change indoor temperatures for extreme weather. If a hot or cold period is predicted, the thermostat can pre-emptively alter the temperature to make the home more comfortable. Outdoor temperature sensors can protect HVAC systems from frost damage in freezing climates. When the external temperature drops near freezing, the thermostat activates heating or defrosting to keep pipes or other important components from freezing. Frost protection preserves the system's integrity and extends its lifespan. Outdoor temperature sensors improve multi-zone heating and cooling systems. The thermostat may dynamically alter zone temperatures to maintain comfort throughout the living space by considering outdoor conditions. This prevents over-conditioning zones with different insulation or solar exposure.

An outside temperature sensor fits the smart house trend. To maximize energy efficiency, the thermostat may communicate with smart devices like blinds and curtains. The thermostat can connect with smart blinds to close them on hot summer days to reduce heat gain and cooling needs. An external temperature sensor allows for more user-friendly features and functions. The thermostat's user interface shows exterior temperature, weather conditions, and forecasts, giving consumers a complete picture of their home's atmosphere. This information helps users optimize energy consumption and temperature settings. In conclusion, adding an outdoor temperature sensor to the Wi-Fi programmable room thermostat improves temperature control, energy efficiency optimization, weather-responsive programming, frost protection, optimal temperature zoning, integration with smart home systems, and user experience. An outside temperature sensor helps the thermostat system maximize comfort, energy savings, and sustainability.

CHAPTER 4 SAFETY OF LIVELIHOOD ACTIVITIES, BASIS OF LABOR PROTECTION

4.1 Safe Methods using the device

It is important the users of the thermostat use it with care and safety. Wi-Fi thermostats require filter maintenance for effective and healthy HVAC functioning. Fibreglass, pleated, electrostatic, and HEPA filters are common. For your HVAC system's filter type, consult the manual or a professional. Follow HVAC processional's filter replacement schedule. Filters should be replaced every 1–3 months, depending on filter type, indoor air quality, occupancy, and pet presence.

Check the filter for dirt, debris, and discolouration. Even before the suggested period, a filthy or clogged filter may need to be replaced. Turn off the thermostat before replacing the filter. Find the filter container near the furnace or return air duct. Remove the old filter carefully, noting its size and orientation. Choose a filter depending on your HVAC system's manual or the old filter's size and specs. If users have allergies or air quality issues, users should use filters with higher MERV ratings. If unsure, consult an HVAC professional about airflow and greater MERV ratings. Washable and electrostatic filters are reusable. To avoid Mold and germs, dry the filter before reinstalling it. Insert the new or cleaned filter into the compartment, aligning it with the airflow direction on the filter. To stop airflow, secure the filter. Check the new filter for airflow and performance for the first few days. After filter replacement, check for sounds, ventilation, and temperature control issues. Consult an HVAC professional for issues. Pet dander and hair require more regular filter replacements. To maintain interior air quality during construction or renovations, check and replace the filter more often. Remember that clean filters increase indoor air quality, system efficiency, and allergen and pollutant reduction. If users have questions concerning filter maintenance, they should see an HVAC professional.

Wi-Fi thermostats prioritize privacy and safety. Protecting your personal data and home network is crucial. Here are way in which you can secure your data safety. Password-protect your home Wi-Fi network. Encrypt your network with WPA2 or higher. Avoid using device-revealing default network names (SSIDs). To prevent illegal access, change your Wi-Fi password frequently. Change your Wi-Fi thermostat's username and password right away should be the go-to if users feel insecure. Use uncommon usernames and password managers to securely store and generate strong passwords. Use two-factor authentication if your Wi-Fi thermostat supports it. Two-factor authentication requires a mobile device code in addition to login credentials. Check manufacturer firmware upgrades for your Wi-Fi thermostat. Security patches improve device performance in firmware updates.

Wi-Fi thermostat that has a remote-control mobile app, get it from official app stores. Installing the app requires verification. Updating the mobile app often improves security. Consider connecting your Wi-Fi thermostat to a guest network on your router. Separating the thermostat from your home network on a guest network adds security. Understand the Wi-Fi thermostat manufacturer's privacy policy. Be aware of data collection, storage, and sharing. Ensure the manufacturer uses encryption and secure data storage. Wi-Fi thermostats may offer data sharing programs. Assess risks and advantages before participation. Check if data sharing programs or services provide opt-outs if privacy is an issue. Wi-Fi thermostat notifications and device activity records should be monitored. Contact the manufacturer's support team for suspicious activities. To avoid tampering, hide the Wi-Fi thermostat. Only authorized people can touch the thermostat.

Update firewalls and antivirus software on all home network devices, including the Wi-Fi thermostat. Scan your network regularly and fix any vulnerabilities. It is important to educate your family about Wi-Fi thermostat privacy and security. Instruct them to keep thermostat login information private.

Following these instructions, will make user feel secure using wifi thermostat or any device connected to the internet.

4.2 Basic of labor Protection

When constructing the WiFi Thermostat it is very important to be safety in mind. There are many ways that during the constructing thing could go wrong. I will talk about so of the safety procedures to use when work on this project. Any electrical endeavor requires electrical safety. Learn voltage, current, resistance, and circuits. This knowledge will aid decision-making and accident prevention. Research requirements, wiring diagrams, and safety guidelines before working on your Wi-Fi thermostat or other electrical installation. Use user manuals, product literature, or electrical engineering references. Before making any changes, turn off the circuit's power. Unplug or turn off the circuit breaker. If possible, utilize lockout/tagout to safely de-energize the circuit or equipment while working on it. Locking the circuit breaker or placing a visible tag indicates maintenance or repairs. Before touching wires, visually inspect them for corrosion, frayed insulation, or loose connections. Replace damaged wiring. Make sure the wire gauge matches the circuit's current and length. Undersized wires overheat and burn. Check wire connections. Loose connections can cause electrical arcing, overheating, and failures.

Use wire nuts or crimp connectors to securely attach wires. Permanent connections should not use electrical tape. Make sure your Wi-Fi thermostat's circuit can manage its power needs. Overloading the circuit can cause overheating and fires. Install appropriate circuit breakers or fuses to prevent overcurrent. If current exceeds a safe limit, circuit breakers disconnect electricity. Follow local electrical codes. Ground your Wi-Fi thermostat and metal components to avoid electrical shocks and fires. Kitchens, baths, and outside installations should have GFCIs. GFCIs detect electrical current imbalances and immediately cut power to prevent electric shocks. Check your Wi-Fi thermostat, electrical connections, and wiring for wear, damage, and overheating. Replace broken parts immediately. To ensure electrical system safety and functionality, schedule frequent expert electrical inspections. If you're unsure about electrical work or lack the skills, ask a licensed electrician. Another safety procedures comes when using tools.

For this project I used Soldering iron and Soldering flux. This are ways to better protect yourself when using this tools. Choose a project-appropriate soldering iron. wattage, temperature control, and tip size. Make sure your soldering iron matches your components. Before using, check the soldering iron for frayed cables, loose connections, and damaged tips. Damaged soldering irons are dangerous. Hold the soldering iron by the insulated handle. Touching the heated point might cause severe burns. Use a soldering iron stand when not in use. The stand should securely hold the soldering iron, preventing accidental contact with combustible items. Wear protective glasses or goggles to avoid solder. Protect your hands with heat-resistant gloves if needed. Wear gloves suitable for soldering temperatures. Lead vapors from lead-based solder can be dangerous. Use a fume extractor or ventilate your workspace. Open windows or use a fan to circulate air when working indoors. Keep and know how to use one. Choose an electrical fire extinguisher. Use a soldering mat or fire-resistant workbench. Keep paper and solvents away from soldering. Unplug the soldering iron while not in use. This prevents fires and burns. Never use a hot soldering iron near water. Soldering irons produce high temperatures and steam or spatter when exposed to water, causing burns or electrical shorts. Avoid electrostatic discharge when handling delicate electronics. To prevent static harm, use an ESD mat or wrist strap. Remove solder debris, excess flux, and other potentially harmful materials. Dispose waste appropriately. Let the soldering iron cool completely before keeping it away from flammable materials and where it could be knocked over. Follow the soldering tool's instructions. Before trying soldering tasks, seek advice from an experienced person or take a soldering safety course.

Working on this project, some precautions have to be observed. There are equipment to use to better protect yourself from any harm. Use ear side-shielded safety glasses or eye protection goggles. They protect your eyes from solder, flux, and debris.

To maximize protection, choose impact-resistant eye-wear that satisfies ANSI Z87.1. Handling hot components or surfaces requires heat-resistant gloves. Insulated gloves defend against high temperatures. To avoid skin contact with hot components or surfaces, wear long-sleeved shirts. Avoid loose clothing that could get trapped in the soldering iron or other equipment, which could cause mishaps. Work in a well-ventilated environment to avoid soldering vapors. Increase airflow using fans or windows. Use a fume extractor to eliminate soldering fumes directly. This prevents hazardous inhaling. If you have respiratory sensitivities or deal with lead-based solder, wear a properly fitting respirator mask rated for soldering vapors. Choose a safety-approved mask. Use electrical-specific insulated pliers or wire cutters. Insulation on these instruments prevents electric shocks when handling live wires or components. Use them on your work surface to prevent accidental contact with hot components or surfaces. This prevents workplace burns. Handle sensitive electronics using an ESD wrist strap or mat. These devices dissipate body static to prevent ESD damage to components. Soldering on an ESD-safe mat or desk reduces static electricity. Soldering can strain your back, neck, and wrists. Work in comfort with an adjustable chair or worktop.

Drink water, especially in hot situations. Hydration prevents dizziness and weariness. Taking breaks during long soldering sessions prevents mental and physical weariness, which can affect safety. Personal protection should be tailored to your project, materials, and equipment. Follow tool and equipment manufacturer safety requirements and local safety norms. Fire safety is very important when working on this project or any electronics in general. It is important to know basic fire safety knowledge to protect yourself and the project.

Keep papers, textiles, and chemicals out of your workspace. Stay away from fire hazards when soldering. For non-flammable soldering, use a soldering pad, ceramic tile, or metal sheet. Keep loose cables off of the soldering area. Avoid inadvertent contact and tripping by keeping them from dangling or touching hot surfaces.

Fire Extinguisher have one handy at work. It should be suitable for electrical fires and easy to use. Choose a Class C electrical fire extinguisher. Use electrical equipment-safe extinguishers. Install the right circuit breakers or fuses to prevent overcurrent. Circuit protection prevents overheating and fires. Check your soldering setup wire for wear and damage regularly. To prevent electrical shorts and sparks, replace frayed wires. Unplug your soldering iron when not in use or on breaks. Avoiding inadvertent touch and overheating. Before storage, let the soldering iron cool. Keep it away from fire and other hazards. Always watch a hot soldering iron. Turn it off and let it cool before leaving. This prevents accidental contact with flammable materials. Know your office's emergency exits. Keep them clear and accessible. Fire evacuation plans should include exit routes and a meeting location outdoors. Shared space-mates should practice the strategy regularly. Install smoke detectors in your house or workplace, especially near soldering or other potentially dangerous operations. Maintain detectors. Install fire alarms in your home or workplace. Check and replace batteries regularly. Keep calm and think logically amid a fire. If the fire is uncontrollable, evacuate immediately. Use the right fire extinguisher: If a little fire is safe to extinguish, do so. Remember "PASS". Pull the pin, Aim at the base of the fire, Squeeze the handle, and Sweep from side to side. If the fire is large or you can't put it out, call your local emergency services and give them exact details. Always follow local fire safety requirements. To be prepared and reduce dangers in your workplace or home, periodically review and renew your fire safety knowledge.

Conclusion

In this project, I create a Wi-Fi programmable room thermostat with an air quality sensor and other capabilities to improve business thermostats. Remote settings and internet connectivity allow consumers to operate their heating and air conditioning systems and improve indoor air quality. This project uses an ESP8266 controller, temperature and humidity sensors, CO2 sensors, a real-time clock, an OLED display, RF modules, relays, and voltage regulators. A complex thermostat system integrates these components. The analyzer and contactor make up the thermostat.

The ESP8266 controller powers the analyzer, the thermostat system's hub. It creates transmitter and screen control signals from temperature, humidity, and CO2 sensors. This lets the thermostat monitor critical environmental parameters. An Arduino Pro Mini module receives signals from an RF receiver and controls the heating device based on the analyzer's threshold values. The thermostat may actively control room temperature. The project enhanced thermostat functioning. Wi-Fi connectivity allows browser-based thermostat control. Users can alter temperature settings, check air conditions, and access numerous functions from any internet-connected location. The thermostat maintains three temperatures throughout the day for personalized heating and cooling programs. It offers humidity and CO2 management, automatic humidification, forced ventilation, and air conditioning. The initiative also monitors air quality.

The thermostat's CO2 sensor correctly measures room carbon dioxide. The thermostat sends email alerts if temperature, humidity, or CO2 levels exceed user-set thresholds. This alerts consumers about air quality issues quickly. The thermostat has an internet-synchronized real-time clock (RTC) to improve functioning. This provides accurate timekeeping and lets users schedule temperature adjustments at certain times. Pre-setting temperature adjustments throughout the day optimize energy economy and comfort. This project emphasizes user-friendly control and monitoring interfaces.

The technology integrates Blynk, a smartphone app that lets users remotely manage and monitor the thermostat. The Blynk app displays real-time temperature, humidity, and CO_2 measurements. The app has virtual buttons for easy temperature adjustments. Using inexpensive components, the project emphasizes cost-effectiveness. The thermostat's components cost $50, making it cheaper than similar commercial thermostats. This cost makes complex thermostat functions more accessible. This project effectively integrates hardware, programming, and connection to build a Wi-Fi programmable room thermostat with air quality monitoring. The project improves functionality, remote control, air quality monitoring, real-time clock synchronization, mobile app integration, and cost-effectiveness. The thermostat system improves heating and air conditioning management and monitoring by improving comfort, energy efficiency, and convenience.

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Appendix A. Technical assignment

MINISTRY OF EDUCATION AND SCIENCE OF UKRAINE
Ternopil Ivan Puluj National Technical University
Faculty of Computer Information Systems and Software Engineering
Computer Systems and Networks Department

“Approved”
Head of department
________ Osukhivska H.M.
“___” ____________2023

TECHNICAL ASSIGNMENT

THE COMPUTERIZED REMOTE CONTROL SYSTEM FOR A PROGRAMMABLE THERMOSTAT

Bachelor’s Degree

“AGREED”	“PERFORMER”
Supervisor	Student of Group ICI-42
________ Yurii Leshchyshyn	________ Ogbera G.E
“___” ____________2023	“___” ____________2023

Ternopil 2023

Terms

This document describes tasks for the development of a computerized remote control system for a programmable thermostat. The goal for this advanced Wi-Fi programmable room thermostat with an integrated air quality monitor is to maximize comfort, energy economy, and indoor air quality..

The full name of the project is the computerized remote control system for a programmable thermostat

1.1 Order For System Development

1.2 Performer

Performer - student of ICI-42 group, department of computer systems and networks, Ternopil Ivan Puluj National Technical University, Ogbera Gabriel Emuesiri.

1.3 Input documents for System development

- Specification of ESP8266 controller
- Specification of DHT22
- Specification of DS3231
- Specification of OLED display
- Specification of MH-Z19 CO2 sensor

1.4 Date of Start And Submitting

Planning date of start -
Submission date -

1.5 The sequence of results presentation

Projects consist of the lists of documentation which responds to the approved requirements of the computer systems and networks department. Requirements response to the standards in the field of computer engineering development (ISO standards).

Presentation of intermediate results of the diploma project is carried out according to the schedule approved by the supervisor.

1.6 Standards and regulatory documents

- Standard ANSI/EIA/TIA 568 - “Commercial Building Telecommunications Wiring Standards” and ANSI/EIA/TIA 569 - “Commercial Building Standard For Telecommunications Path waisand Spaces”

2 Appliance and Purpose Of System Design

2.1 Appliance Of System

Wi-Fi thermostats allow remote HVAC system control. Remotely alter temperature, settings, and schedules from home or away. Adjusting the temperature to your preferences and occupancy patterns saves energy and keeps you comfortable. Wi-Fi thermostats often have smart scheduling.

2.2 Objective Of The System Design

Wi-Fi thermostats commonly work with smart home systems. They provide voice control of the thermostat via Amazon Alexa or Google Assistant. Apple HomeKit and Samsung SmartThings allow you to automate routines and control your thermostat and other connected devices.

2.3 Characteristic of Design Object

The system should be based on ESP8266 controller on the NodeMCU CP2102 module board.

3 System’s Requirement
3.1 Requirements in general
3.1.1 Requirements to the system structure and system operation
The analyser brain is an ESP8266 controller on the NodeMCU CP2102 module board. Sensor signals control the transmitter and screen. Install the DHT22 temperature and humidity sensor on the board away from heat-dispersing elements to reduce temperature measurement mistakes.

3.1.2 Channels of system components communication
Data exchange should take place through digital radio modems at the frequency of 433 MHz.

3.1.3 Requirements to the modes of system operation (normal mode (reliability), emergency mode)

3.1.4 Requirements to the system diagnostic

In order to diagnose the system, it must be monitored using the appropriate tools included in the relevant system software. The tools should provide an easy interface for viewing diagnostic events and monitoring the program execution process.

3.1.5 Perspective of modernization

The system software can be modified to newer versions, the microcontroller can also be replaced with an updated model. Additionally, the other components can be replaced with newer and better versions as time passes. The program code can also be modified to make room for additions of other components.

3.1.6 Requirement to the end users and their qualification

System administrators maintain the system in automatic or manual mode through management and monitoring. The minimum number of service personnel is one person.

3.1.7 Criteria of appliance

The system must be able to scale:

- By productivity
- By capacity of information process
- Scaling capabilities must be provided by the basic software and hardware used.

3.1.8 Reliability requirements

The system must be operational and restored in the following situations:

- If a sensor outlives its usefulness, it must be replaced as quickly as possible
- When there is a problem with the microcontroller, the reset button can be activated to restart the system. This restart can be all that the problem needs in order to start working properly.

3.1.9 Safety Requirements

The external elements of the technical measures of the system, which are under voltage, must have protection against accidental contact, and the technical measures themselves must have a zeroing or protective grounding GOST 12.1.030-81 and PUE. The power supply system must provide a protective switch during overloads and short circuits in the load circuits, as well as manual emergency shutdown. General fire safety requirements must comply with the standards for household electrical equipment. In the event of fire, no poisonous gasses or vapors should be produced. After disconnecting the power supply, ensure that all fire extinguishers can be used. Harmful factors should not exceed the standards of SanPiN 2.2.2./2.4.1340-03 of 06/03/2003.

3.1.10 Requirements for operation, maintenance, repair and storage of system components

The microclimate in rooms with the corresponding hardware has to correspond to norms of an industrial microclimate (GOST 12.1.005-88).

For normal operation of the network it is necessary to support (according to GOST 23.865-85):

air temperature in the range from + 15C to + 20C;

relative humidity at 20 C in the range from 30% to 70%;

atmospheric pressure 760 mm Hg.

The technical means used must be regularly maintained according to the requirements of the technical documents, but not less than once a year. Regular maintenance and testing of technical means should include maintenance and testing of all used means, including workstations, servers, cable systems and network equipment, and uninterrupted power supplies. According to the test results of technical means, the reasons for the defects should be analyzed and eliminated. The location of the premises and its equipment must prevent uncontrolled entry by outsiders and ensure the security of confidential documents located in these premises and technical means.

3.1.11 Requirements to standardization and unification

The ESP8266 controller on the NodeMCU CP2102 is a microcontroller that can be used for multiple purposes and has important features

- It is light and energy efficient
- It is very versatile
- It is programmable and configurable
- It has great connectivity

3.2 Requirements for types of collateral

3.2.1 Requirements to the system's hardware (technical characteristics of each devices in the system)

The system consists of an ESP8266 controller on the NodeMCU CP2102, and many others.

3.2.2 Structure and Contest of design system

The composition and content of system design work includes: (translate)

- design and coordination of the technical task for the system;

- system design;
- writing an explanatory note;
- design of graphic material;
- Defense of the qualifying paper.

4 Technical and economic indicators

The cost of development should not exceed 8000 UAH
The service life of the system should be at least 22,000 thousand hours. (2 years)

5 Stages of system design

Number of Stage	Stage	Duration
1	Development and approval of the technical task	
2	Analysis of the technical task	
3	Substantiation of possible technical solutions	
4	System design and implementation	
5	Testing of the designed system	
6	Section of labor protection and safety in emergency situations	
7	Registration of the qualifying paper	
8	Preliminary defense of the qualifying paper	
9	Defense of the qualifying paper	

6 The order of control and acceptance

The control of the process of execution of the diploma project is carried out by the head of the diploma project.

Normal Control of the diploma project for compliance with the requirements of the standards is carried out at the Department of Computer Systems and Networks.
The presentation of the results of the diploma project is done by defending the diploma project at the relevant meeting of the SEC, illustrating the main achievements through the graphic material.

7. Requirements for documentation

The documentation must meet the requirements of ESKD and DSTU Set of design documentation:

- explanatory note;
- applications;
- graphic material;

a) wiring diagrams of the device board through specialized interfaces;
b) block diagram of the device components;
c) algorithms of the created software;
d) block diagram of the device software;
e) the deployment scheme of this solution.

8 Additional Conditions

During the implementation of the thesis project, changes and additions may be made to this technical task.

APPENDIX B. Program Code

B.1 Code for Contractor

```
/*
Wi-Fi programmable room thermostat with air quality monitor
Contactor

  */

#include <RCSwitch.h>     // https://github.com/sui77/rc-switch
RCSwitch
  mySwitch = RCSwitch();

void setup() {
      pinMode(13, OUTPUT);
      pinMode(3,
  OUTPUT);
      pinMode(4, OUTPUT);
      pinMode(5, OUTPUT);
      pinMode(6,
 OUTPUT);

      digitalWrite(3, HIGH);
      digitalWrite(4, HIGH);

      digitalWrite(5, HIGH);
      digitalWrite(6, HIGH);
      digitalWrite(13,
  LOW);

      mySwitch.enableReceive(0);
    }

void loop() {

       if( mySwitch.available() ){
        int value = mySwitch.getReceivedValue();


              //t < Tmin
        if(value == B11111110) digitalWrite(4, LOW);

        else if (value == B10000000) digitalWrite(4, HIGH);

                //co2
  > Cmax
        if(value == B11111101) digitalWrite(5, LOW);
        else



 if (value == B00000010) digitalWrite(5, HIGH);

             //h < Hmin
```

```
        if(value == B11111011) digitalWrite(6, LOW);
        else if (value ==
  B00000100) digitalWrite(6, HIGH);

          //t > Tmax
        if(value
  == B11110111)digitalWrite(3, LOW);
        else if (value == B00001000) digitalWrite(3,
  HIGH);

        // LED D13 Arduino - indicates the presence of a transmitter-receiver
  connection (blinks - there is a connection)
        if(value == B10101010) digitalWrite(13,
  HIGH);  //  B10101010 - transmitter enabled code, generated in the analyzer without
  conditions
        else  digitalWrite(13, LOW);

        mySwitch.resetAvailable();
  }
}
```

B.2 Back-end code

```
<?php
// Wi-Fi programmable room thermostat with air quality monitor
mymail=my_login@my.site.net&t=22.2&h=55&co2=666
$EMAIL=0;
$TEMPER=0;
$vlaga=0;
$carbon=0;
$device=0;
$EMAIL=$_GET["mymail"];
$device=$_GET["ID"];
echo  $EMAIL;
$TEMPER=$_GET["t"];
$vlaga=$_GET["h"];
$carbon=$_GET["co2"];


$mdate  = date("H:i d.m.y");
echo <<<END
<p>Temperature:  $TEMPER °C<p>
<p>Humidity:  $vlaga %<p>
<p>Carbon dioxide content:  $carbon ppm<p>
<p>--------------------<p>
<p>Meteostation:  $device<p>
END;
echo <<<END
<p>$mdate</p>
END;
mail($EMAIL, "Air  Quality Monitor " .$device. " v.051018","   This message was generated
automatically  by air quality monitor " .$device.    "One or more room air parameters (temperature,
humidity or carbon dioxide content) are outside the specified limit values. ===  Temperature:
".$TEMPER."°C === "."Humidity: ".$vlaga."% === "."Carbon dioxide  content: ".$carbon." ppm ===
"."Analyze the information! === Date: ".$mdate,"From:  my_sensors@air-monitor.info \
")
```