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REPORT AUTOMATISM AND INDUSTRIAL DATA PROCESSING

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Contents

List of Figures

List of Tables

1 OVERVIEW

Reason for choosing the topic:

In the latest years, with the advancement of technologies, our civilisation has been changing drastically. Along with the improvement of technology, many automatic applications have appeared with high accuracy and security, hence make an important role in daily life.

In the field of automatism, microcontroller engineering has became familiar. Most large automated production lines and consumer products feature the presence of microcontrollers. Modern microcontrollers are highly advanced, incorporating numerous features and diverse peripherals along with robust processing capabilities to handle complex tasks. Moreover, wireless communication technology is also being improved. For that reason, our group decided to research the topic: **"DESIGNING A COMMUNICATION SYSTEM WITHOUT CONTROL AND MONITORING HEAT AND HUMIDITY USING BLUETOOTH TECHNOLOGY"**

Our report will be divided into 3 main different parts:

- Part 1: Theoretical basic
- Part 2: System design
- Part 3: Evaluate performance and results

2 THEORETICAL BASIS

2.1 Overview of Bluetooth

2.1.1 Basics of Bluetooth

Bluetooth is a wireless short-range technology standard integrated into electronic devices. It facilitates data exchange between personal electronic devices such as PCs, smartphones, etc., at close distances without the need for cable transmission support while still ensuring security.

Today, most factories produce devices that use Bluetooth technology: mobile phones, laptops, tablets, and other personal support devices. This technology is expected to be the key to IoT (Internet of Things) products.

History of Formation:

- Bluetooth is named after the Danish king Harald Bluetooth.
- In 1994, Sony Ericsson proposed a communication standard between electronic devices without using wires.
- In 1998, Ericsson, Nokia, IBM, Intel, and Toshiba introduced the Bluetooth standard. On May 20, 1998, the SIG group was established to develop Bluetooth in the telecommunications market.
- In 1999, the first commercial version of Bluetooth targeting ordinary users was launched, marking the birth of the first Bluetooth standard.

Main Bluetooth Specifications:

- Standardization: IEEE 802.15.1
- Operating frequency band: Radio waves with frequencies from 2.4 GHz to 2.480 GHz
- Data transmission speed: 1 Mbps.
- Range: 50 -150m (Smart, BLE)

2.1.2 Advantages and Disadvantages of Bluetooth

Advantages:

- Wireless device connectivity
- Secure encryption technology for safety
- Low energy consumption
- Cost-effective
- High compatibility, easily integrated into many devices and supported by many hardware and software manufacturers

Disadvantages:

- Low transmission speed, maximum about 720 kbps.
- Poor reception in the presence of obstacles.
- Lengthy setup time.
- Limited number of connections
- Short connection range
- Susceptible to interference from other devices using radio waves

2.1.3 Bluetooth Versions

Bluetooth 1.0: The initial Bluetooth version with a speed of 1 Mbps, but limited compatibility.

Bluetooth 1.1: An improvement over 1.0, addressing its flaws but not enhancing speed.

Bluetooth 1.2: An upgrade of Bluetooth 1.0 with improvements in connection speed and transmission.

Bluetooth 2.0 + EDR: Introduced in July 2007 with increased stability and faster data sharing, saving more energy compared to previous versions.

Bluetooth 2.1 + EDR: An upgrade of Bluetooth 2.0 with a mechanism for smaller range connections.

Bluetooth 3.0 + HS: Launched in 2009 with a theoretical speed of up to 24 Mbps. Bluetooth 3.0 was widely used in mobile phones at that time, suitable for transferring small data like images, music files, etc.

Bluetooth 4.0: Bluetooth 4.0, released on June 30, 2010, optimized previous Bluetooth standards (Classic Bluetooth) for high-speed transmission via Bluetooth High Speed and lower energy consumption through Bluetooth Low Energy.

Bluetooth 5.0: The latest generation introduced by SIG on June 16, 2016, with significant improvements such as four times wider coverage range, double the speed, and 2.5 times power savings compared to 4.0.

Bluetooth 5.1: Enhanced with the ability to determine Angle of Arrival (AoA) and Angle of Departure (AoD) for precise device positioning. Additionally, Bluetooth 5.1 features connectionless data packets for simpler, more efficient connections with less power consumption.

Bluetooth 5.2: Introduced in 2020 with Advanced Attribute Protocol (EATT) for reduced latency and increased connection encryption, LEPC control feature for signal stability and power management, decreased signal reception error rate, and ISOC feature enabling bidirectional data transmission with multiple devices simultaneously.

2.2 Wireless Communication Standards and Communication Standards in Bluetooth

The IEEE proposed the 802.15 standard to divide WPAN networks based on transmission speed, energy consumption, service quality, etc. Specifically:

- High-speed WPAN (IEEE 802.15.3 standard) is suitable for multimedia applications requiring high-quality service.
- Medium-speed WPAN (IEEE 802.15.1 / Bluetooth standard) is applied in networks from cellular phones to pocket PCs and provides appropriate QoS for voice information.
- Low-speed WPAN (IEEE 802.15.4 / LR-WPAN) is used in industrial products with limited lifetimes, medical applications that require low energy consumption, and do not require high transmission speed and QoS. The low data transmission rate allows LR-WPAN to consume less energy. In this standard, Zigbee/IEEE802.15.4 technology is a typical example.

Comparison between wireless communication standards:

	802.15.1 Bluetooth	802.15.3 UWB	802.15.4 Zigbee	802.11 Wifi
Work dis	1-3	1-10	1-100	1-100
Net nodes	7	4000	¿64000	32
Common apps	web, mail	Video HD, 4K	Monitoring, ctrl	Replacing Ehtnet
Bandwidth(kb)	250	500000	4-32	1000
Speed(kbps)	720	480000	20-250	11000
Frequency	2.4-2.8	3.1-10.6	0.868-2.45	2.4-5

Table 1: Comparison table

2.3 Principles of Bluetooth Operation

2.3.1 Overview of Bluetooth Network Model

In a Bluetooth network, we have the concept of a Piconet, defined as an area where two or more devices are connected to each other. In a Piconet, one device acts as the Master, usually the device that initiates the connection, while the other devices act as Slaves. The Master is unique in a Piconet and is responsible for establishing a clock to synchronize with other devices in the Piconet; slaves do not communicate with each other. The role of the Master in a Piconet is not fixed; for example, when resources are insufficient, it can be relinquished to a qualified slave to take over as the Master.

When two or more Piconets combine for communication, we have a Scatternet model, which has two types of Scatternet:

A Slave in one Piconet is a slave in another Piconet. In this case, the Piconets operate independently, asynchronously. This model increases packet loss interference. These Piconets synchronize with each other regarding clock and frequency hopping, gradually synchronizing the two Piconet networks.

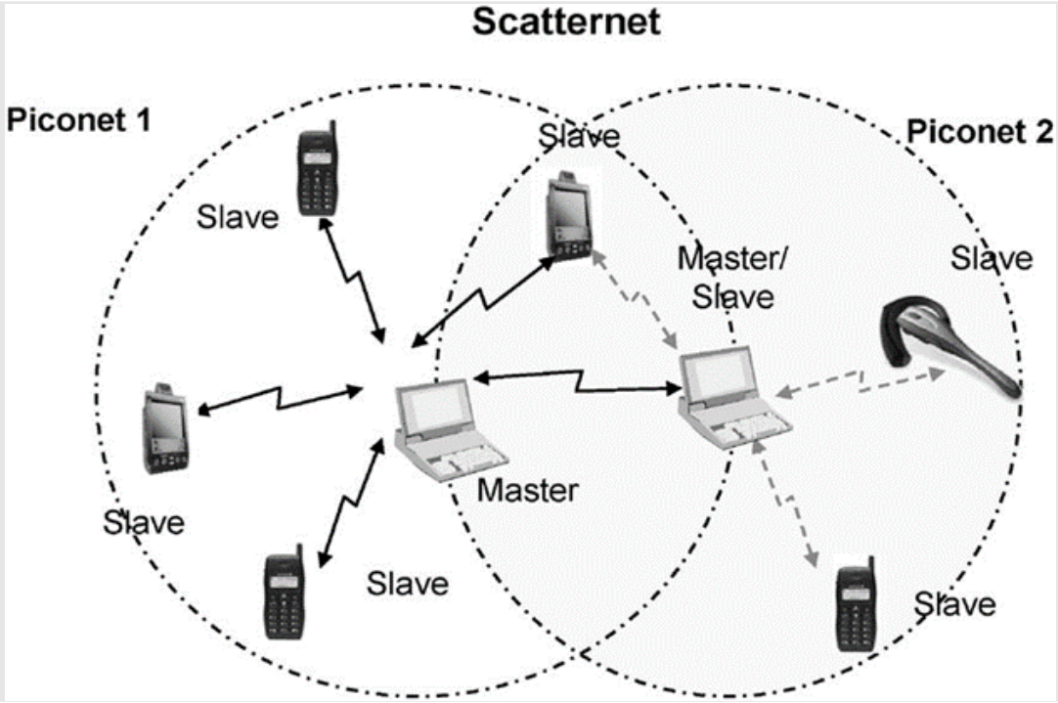

Figure 1: Arduino Uno R3

2.3.2 Bluetooth Communication Mechanism

Bluetooth Radio Waves: Bluetooth radio waves are transmitted using the "frequency-hopping spread spectrum" method, meaning that packets are transmitted on different frequencies.Fast hopping rates improve security and effectively avoid interference.Bluetooth communicates with each other using the Master-Slave protocol.

2.4 Applications of Bluetooth in Wireless Communication

- Establishing wireless networks between computers within a short range.
- Present in: barcode scanners, traffic monitoring devices, medical equipment, etc.
- Replacing infrared remote controls.
- Connecting computers to peripherals.
- Connecting entertainment devices.
- Internet of Things.
- Transmitting files between personal devices.

2.5 Divide work within the group

Column 1	**Column 2**
Row 1	Row 1
Row 2	Row 2
Row 3	Row 3
Row 4	Row 4
Row 5	Row 5

Table 2: Table Caption

3 SYSTEM DESIGN

3.1 Requirements

- Fully design the control system to monitor temperature and humidity.
- Use Bluetooth technology to send the data.
- Make the system work accurately, be compact, and easy to upgrade or improve.
- Provide easy access to expert knowledge for users.

The key point is that this system uses wireless Bluetooth tech to track important environmental conditions, and it needs to be reliable, compact, and able to be updated easily. It also should make it simple for people to access the professional information they need to use the system effectively.

The main focus is on creating a functional, user-friendly system that can monitor conditions and share data wirelessly, while also being flexible and providing access to relevant expertise.

3.2 Block Diagram

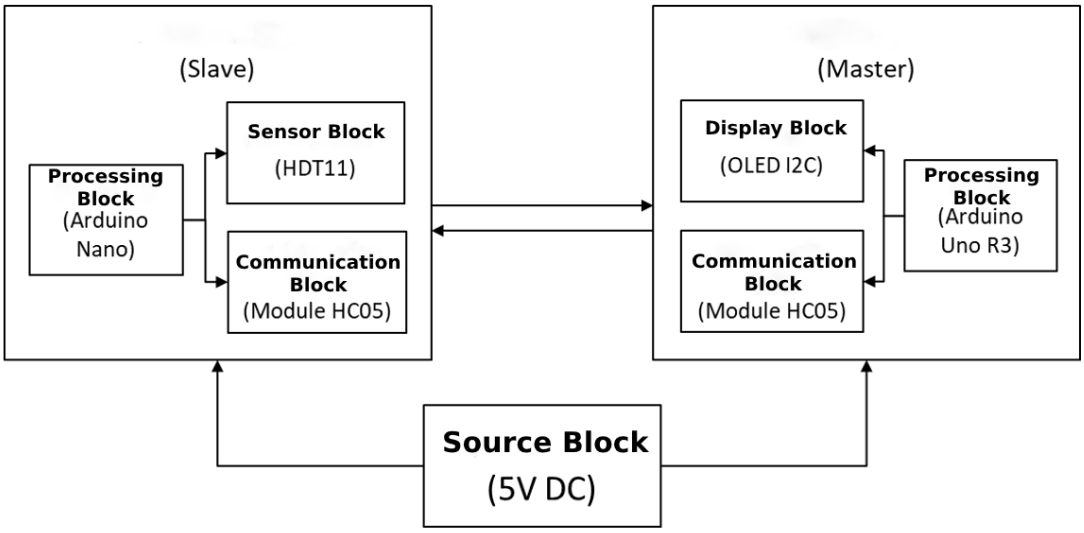

Figure 2: Block diagram

- Source block: Source for components in a stable operation circuit.
- Transmission equipment:
  - Sensor block: Measuring temperature, air humidity with DHT11 sensor.
  - Processing block: Read the temperature, humidity from the sensor.
  - Communication block: Use Bluetooth technology (Module HC05) to connect and send data to Master.

- Receiving equipment:
  - Communication block: Use Bluetooth technology to connect to Slave to create a network environment and receive data from the transmission device.
  - Processing block: Read the value chain received and export the exact value to the display block.
  - Display block: Display the value on the OLED screen.

3.3 Components

3.3.1 Arduino Uno R3

The Arduino Uno R3 is an upgraded version of the Arduino Uno kit that's designed to handle more complex control applications. It has stronger hardware with different types of memory, like ROM, RAM, and Flash, which allow it to store and process more information. It also has many input/output pins that can handle various tasks, like producing PWM signals and reading analog signals. The Arduino Uno R3 can communicate with other devices using different standards, such as UART, SPI, and TWI (I2C). Overall, these improvements make it a versatile and powerful tool for programming and controlling different systems.

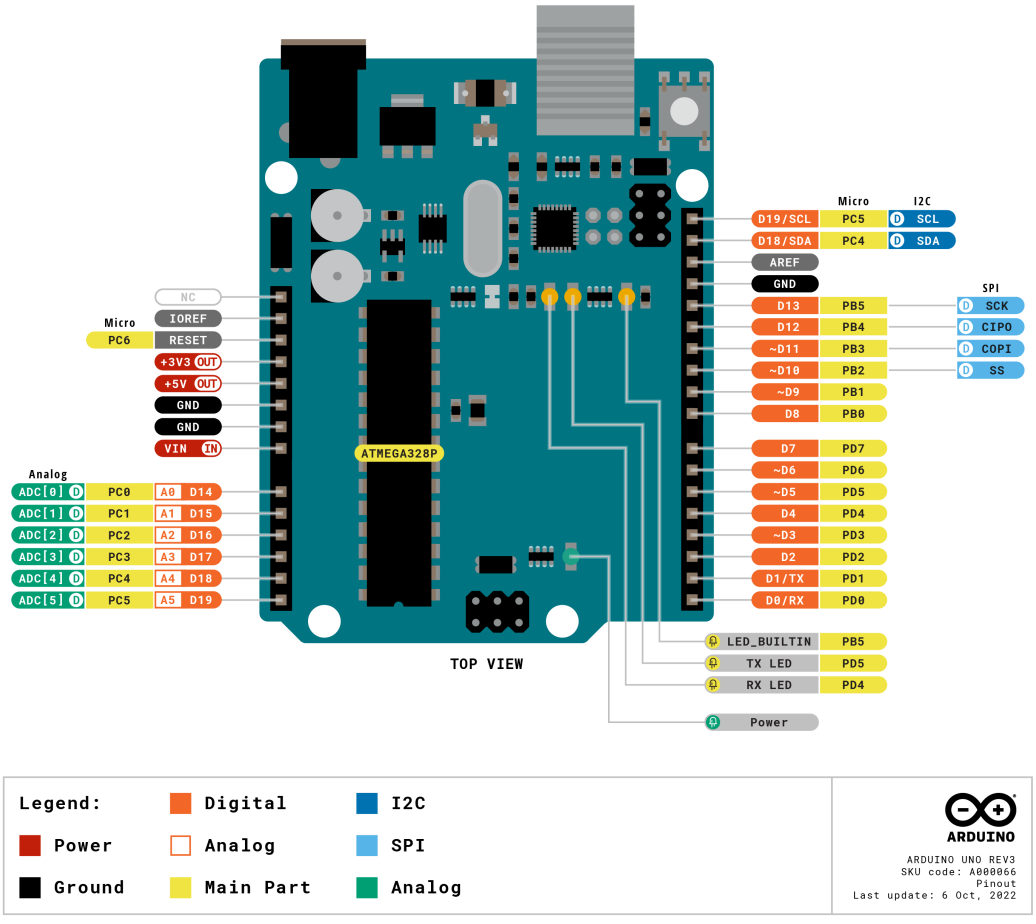

Figure 3: Arduino Uno R3

Parameters:

- Microcontroller: Atmega328 8bit
- Operating voltage and consumption current: 5V DC (USB) - 30mA
- Operating frequency: 16 MHz
- Memory:
  - Flash: 32kb
  - Sram: 2kb
  - EEPROM: 1KB
- Number of digital pins I/O: 14 pins
- Analog pins: 6 pins (10bit)

Arduino Uno is a powerful programming kit with the Atmega328 chip. It has ample RAM and flash memory, meaning it can store and process a significant amount of information. With a wide range of useful resources available, the Arduino Uno is often considered the top choice for designing projects and programming tasks. Its versatility and suitability make it an excellent option for various applications.

3.3.2 Arduino Nano

The Arduino Nano is a smaller version of the Arduino Uno that utilizes the MCU (Microcontroller Unit) atmega328p-Au. It retains all the functionalities and capabilities of the Arduino Uno, which means that any features or programs designed for the Arduino Uno can be used seamlessly with the Arduino Nano. Despite its compact size, the Arduino Nano offers the same level of compatibility and versatility, making it a convenient choice for projects where space is limited.

Parameters:

- Main IC: ATMEGE328P-AU (communication via IC CH340)
- Premium voltage: 5VDC USB or 6-9VDC RAW.
- GPIO communication voltage and current: TTL 5VDC - 40mA
- Number of pins Digital: 14 pins, including 6 PWM pins
- Number of analog pins: 8 pins (more than Arduino Uno 2 legs)
- Flash Memory: 32KB (2KB Bootloader)
- Sram: 2kb
- EEPROM: 1KB
- Clock Speed: 16MHz

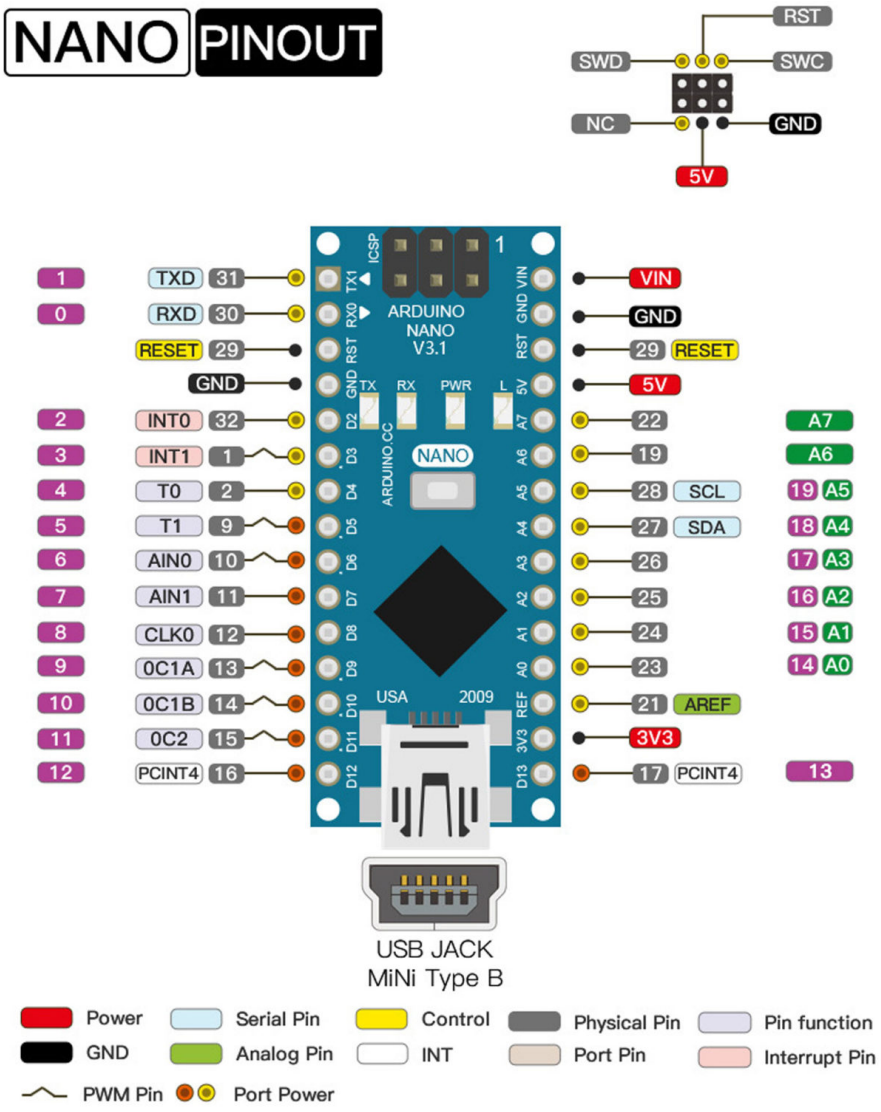

Figure 4: Arduino Nano

The Arduino Nano is a tiny version of the Arduino Uno programming kit. It has all the same functions and abilities as the Arduino Uno, so you can do the same things with it. The special thing about the Arduino Nano is that it's really small, which makes it great for projects where space is limited. Its small size means it can fit into small designs easily. That's why the Arduino Nano is the best and most suitable programming kit for designing projects that need a compact and efficient solution.

3.3.3 Module Bluetooth HC05

The Bluetooth HC-05 transceiver module is commonly employed to establish a serial connection between two devices using Bluetooth technology. One notable characteristic of the HC-05 module is its ability to operate in two distinct modes: Master or Slave. In the Master mode, the module assumes control and initiates the connection with other Bluetooth devices. On the other hand, in the Slave mode, the module awaits a connection request from another Bluetooth device. This flexibility allows the HC-05 module to adapt to various communication scenarios, making it a versatile choice for establishing Bluetooth connections between devices.

Parameters:

- Operating voltage: 3.3 - 6V
- Activity: 30mA (when Paring), 8mA (after Paring)
- Current: 100mA (activity), 8mA (standby mode)
- Bluetooth protocol: Bluetooth v2.0 + EDR
- Frequency: 2.4GHz ISM
- Transmission speed:
  - Asynchronous: 2.1 Mbps/160kbps
  - Synchronization: 1Mbps
- Security feature: authenticity and encryption

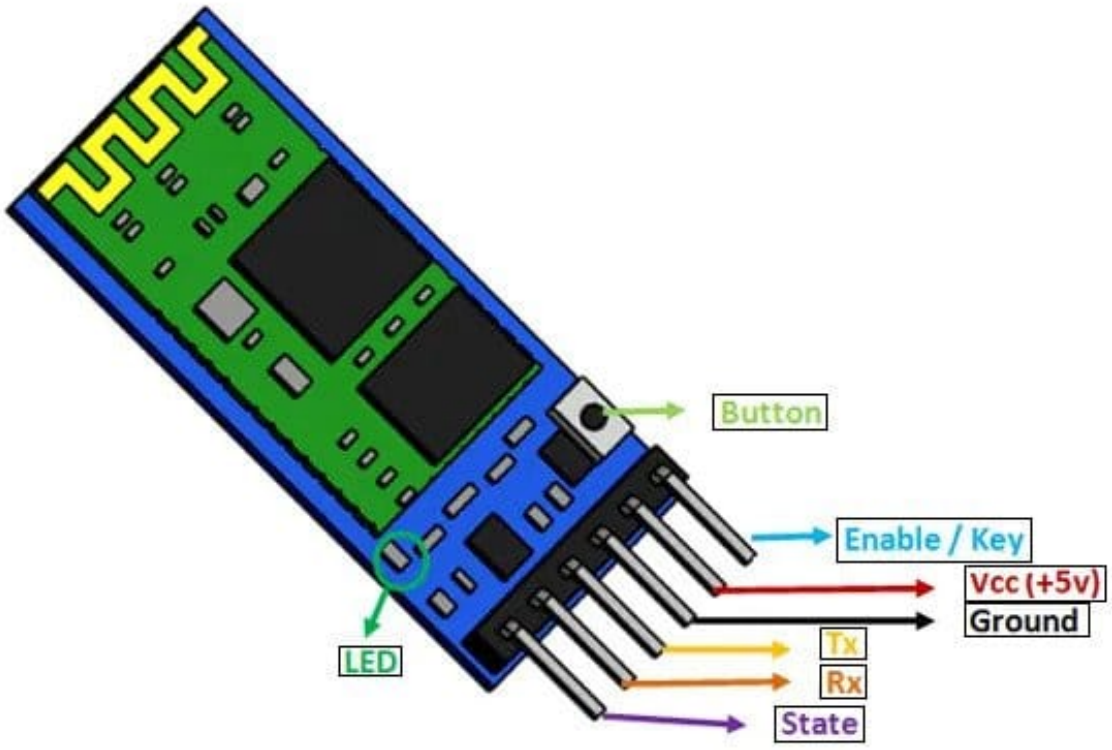

Figure 5: Module Bluetooth HC05

The HC-05 Bluetooth device stands out as a top choice when it comes to wireless communication using the UART communication protocol. It utilizes Bluetooth 2.0+EDR technology, making it highly suitable for transmitting and receiving data through Bluetooth wireless connections. The HC-05 excels in providing a reliable and efficient means of wireless communication, enabling seamless data transfer between devices. With its strong performance and compatibility, the HC-05 is considered the most suitable device for establishing Bluetooth connections and facilitating wireless data transmission.

3.3.4 Digital humidity and temperature sensor DHT11

The DHT11 sensor for measuring humidity and temperature is very popular nowadays because it is inexpensive and easy to use. It uses a simple digital communication method called 1-wire communication, which means it only needs one wire to transmit data. The sensor has a built-in processor that ensures accurate data without needing any complex calculations. This makes the DHT11 sensor a widely chosen option for measuring moisture and temperature in many different projects and applications.

Parameters:

- Source: 3 → 5 VDC.
- Line used: 2.5mA Max (when transmitting data).
- Moisture measurement: 20% - 90% RH (5% error)
- Temperature measurement range: 0 - 50°C (error 2°C)
- Maximum sampling frequency: 1Hz (1 second/ time)
- Size: 15mm x 12mm x 5.5mm

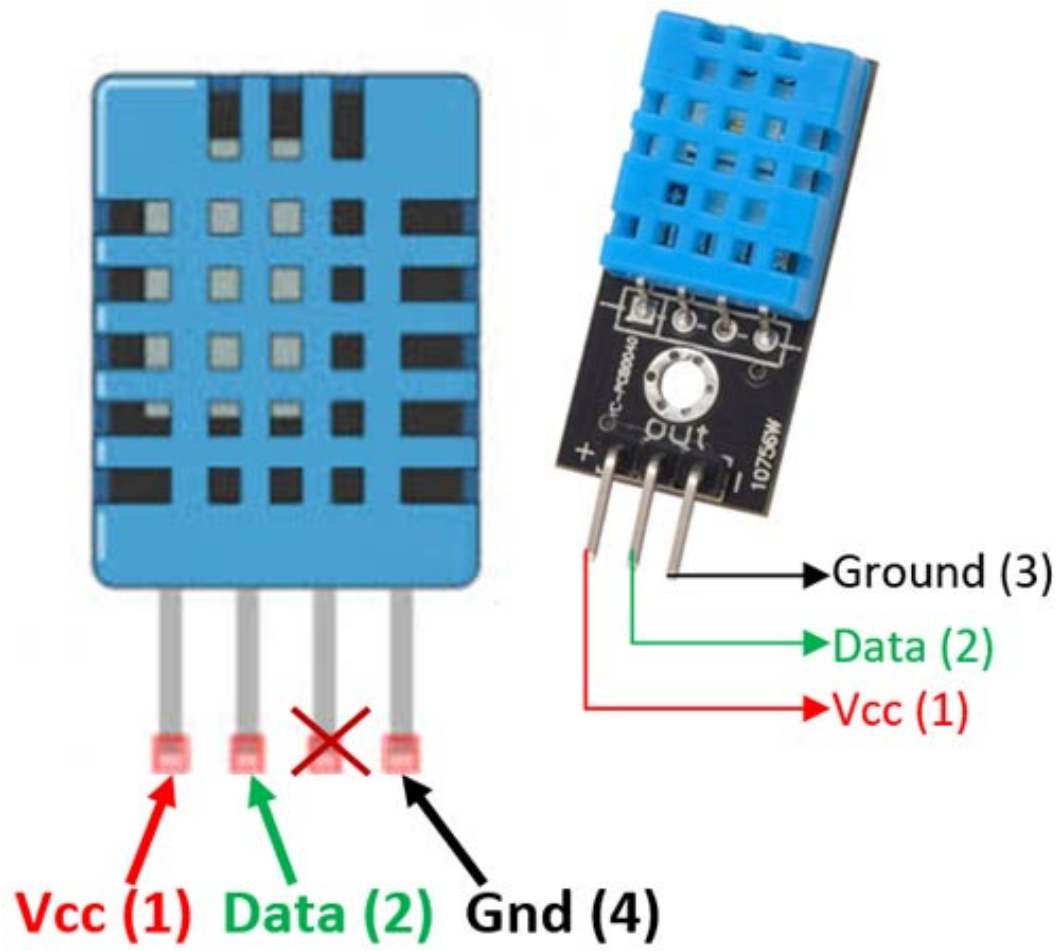

Figure 6: Digital humidity and temperature sensor DHT11

The DHT11 sensor is a straightforward solution for measuring temperature and humidity levels. It is user-friendly, making installation and connection processes hassle-free. Moreover, the DHT11 sensor is compatible with a wide range of microcontrollers commonly used today. This compatibility factor makes it an ideal choice for various projects and applications. With its simplicity and versatility, the DHT11 sensor stands out as the most suitable option for temperature and humidity measurements.

3.3.5 OLED 1.3" I2C

The I2C LCD screen offers a high-quality display at an affordable price. It utilizes I2C communication, which ensures stable and reliable data transmission with minimal wiring requirements. This makes it extremely easy to communicate with the screen. On the other hand, OLED screens are well-suited for energy-saving applications and environments that require a bright and luxurious display. They provide excellent visibility while consuming less power compared to other display technologies. Whether you need a clear and visually appealing display or an energy-efficient solution, both the I2C LCD screen and OLED screen are suitable choices for different applications.

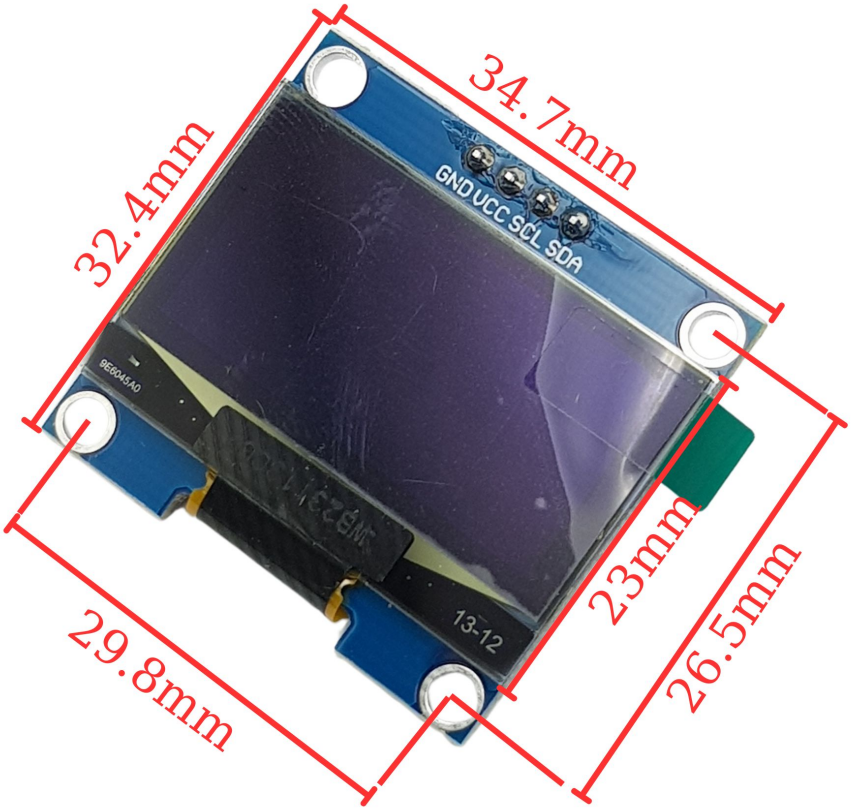

Figure 7: OLED screen 1.3" I2C

Parameters:

- Used voltage: 2.2 $\tilde{5}$.5 VDC
- Power consumption: 0.04W
- Display angle: >160 degrees
- Display number: 128x64 points
- Screen width: 1.3 inches
- Show color: White
- Communication: I2C Driver SH1106

This component, with its high pixel density, enables the depiction of intricate details with sharpness. It offers a wide viewing angle, ensuring clear visibility in various environmental conditions. Additionally, its compact size and utilization of I2C communication help conserve system resources during the design phase. Overall, this display component is the optimal choice for designing the display block of the system, providing excellent visual quality while maximizing resource efficiency.

3.4 Principle Diagram

Transmission equipment:

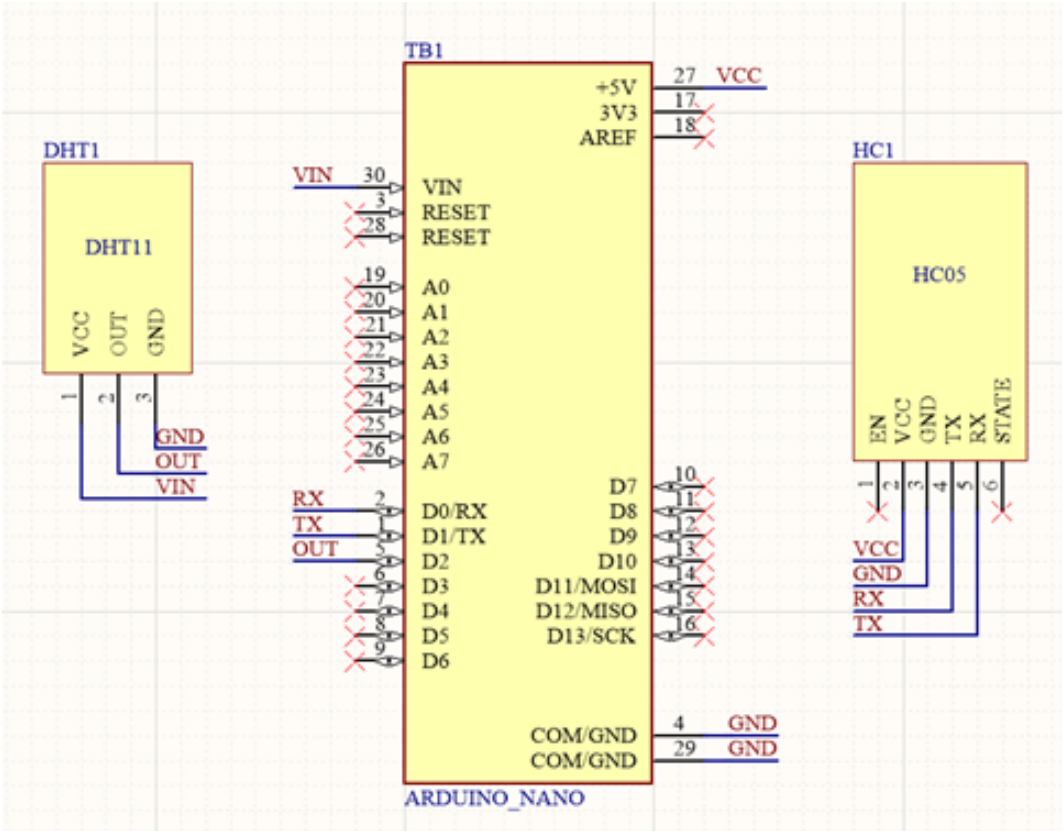

Figure 8: Principle diagram of transmission equipment

Acceptance equipment:

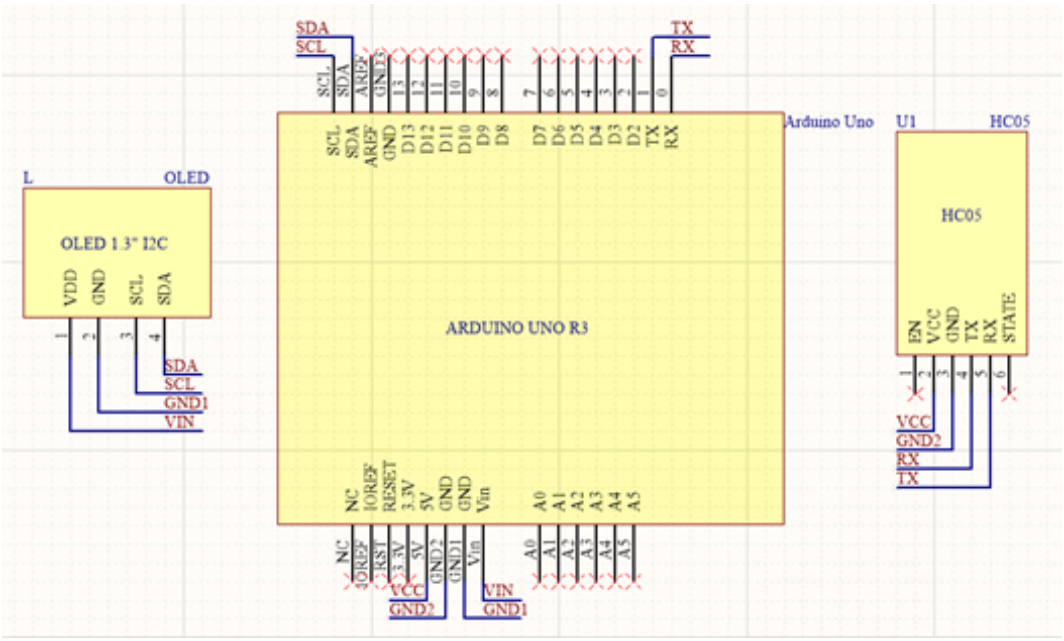

Figure 9: Principle diagram of acceptance equipment

3.5 Connection Diagram

Transmission equipment:

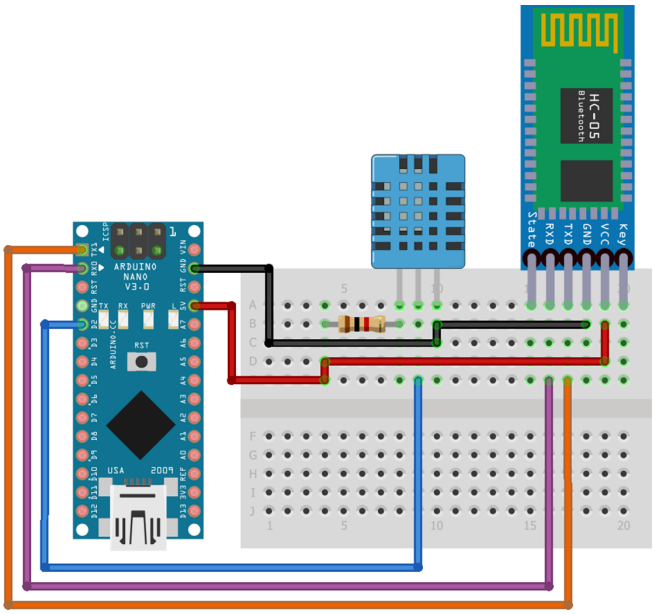

Figure 10: Connection diagram of transmission equipment

Acceptance equipment:

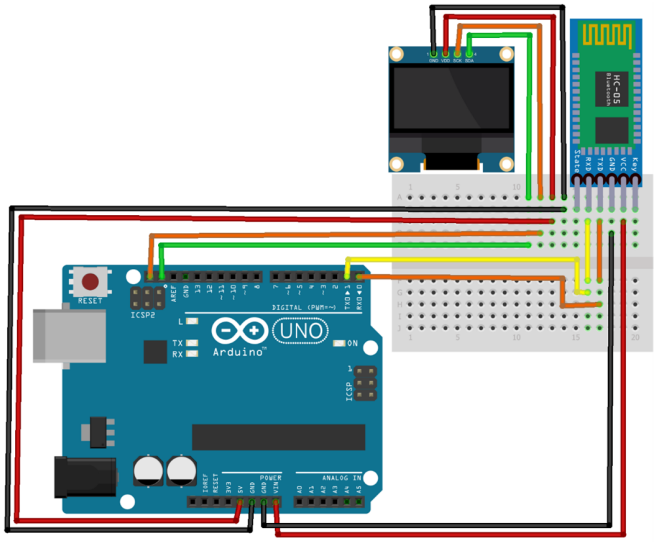

Figure 11: Connection diagram of acceptance equipment

4 PERFORMANCE AND RESULTS EVALUATION

4.1 Performance evaluation

Evaluate the performance of a temperature & humidity control system using Bluetooth wireless connection

- System components:

Components	Quantity
Sensing temperature and humidity	01 pcs
Module Bluetooth HC05 (master)	01 pcs
Module Bluetooth HC06 (slave)	01 pcs
OLED screen 0.96 inch	01 pcs
Adruino Uno R3 Circuit board	01 pcs
Adruino Nano V3.1 CH340 Circuit board	01 pcs

Table 3: System component table

- System testing conditions:
- Distance
- There is an obstacle
- There are no obstructions
- Bluetooth interference from peripheral devices (phone, wifi router)
- System evaluation criteria:
- Communication delay
- Stability

Distance	Obstacles	No obstructions	Interference fr P.C	Communication delay	Stability
5m		✓		$< 0.25s$	Good
5m	✓			$< 0.3s$	Good
5m	✓		✓	$< 0.3s$	Good
10m		✓		$< 0.25s$	Good
10m		✓		$< 0.3s$	Medium
10m		✓		$< 0.25s$	Medium
$> 10m$	✓			$< 0.3s$	Short
$> 10m$	✓		✓	$< 0.3s$	Bad
$> 10m$	✓		✓	$< 0.25s$	Bad
> 10		✓		$< 0.3s$	Bad

Table 4: Communication performance evaluation table

- The delay in transmitting information and the delay in displaying parameters on the display screen are different.
- Display delay on OLED screen from 1.2s to 3s
* Evaluation:

- With a distance of 5m: the system works well with low communication latency and high stability in the presence/absence of obstacles. Latency increases slightly when there is interference from peripheral devices such as wifi routers or Bluetooth transmitters such as mobile phones.
- At a distance of 10m, the system operates with higher latency than at a distance of 5m, but the stability of information transmission is still good. Higher latency from interfering peripherals than within 5m distance.
- With distances greater than 10m: the system is stable with large latency and low stability in the absence of obstacles. Poor latency and stability when there are obstacles. Latency and stability are especially high when there are influences from other peripheral devices * Explain the reasons for causing interference and reducing transmission quality:
Due to hardware connection limitations, the Bluetooth Module HC05 (master) and Bluetooth Module HC06 (slave) have an operating distance of 105m radius, so when going out of range, the connection has high latency and is less stable. In addition, due to obstacles and interference from other devices using the same frequency, the device cannot determine the transmission path.

4.2 Result

Actual circuit running results:

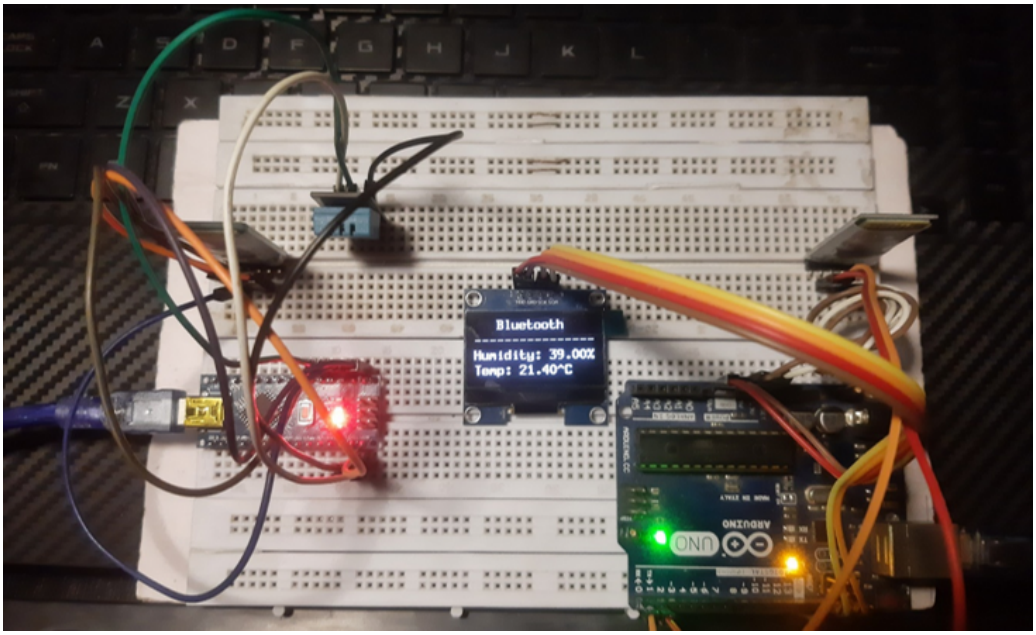

Figure 12: Actual circuit running results

* Results achieved:
• Research, design, build and develop a complete wireless communication temperature and humidity monitoring system using Bluetooth technology.
• The system operates according to the original design.
• Apply the knowledge learned and researched in developing the topic and gain more experience in researching and designing electronic products.
* Difficulties and advantages when implementing the project:
* Advantages:
• The dedicated help of subject teachers, especially Prof. Thanh Hoa PHAN

• There are many related sources of documents for learning and research.
* Difficulty:
• Materials and components are difficult to access due to scarcity of goods.
• Difficulty in referring to foreign language documents due to limited professional foreign language proficiency.

5 REFERENCES

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