WWW.IJRPR.COM

International Journal of Research Publication and Reviews

Journal homepage: www.ijrpr.com ISSN 2582-7421

Designed a Radio Digital Data Transmission System for Measurement and Display of Environmental Parameters

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DOI: https://doi.org/10.55248/gengpi.2022.3.5.9

A B S T R A C T

With the strong development of most industries, such as industry, agriculture, forestry, service, etc., measuring and monitoring environmental parameters has become more and more important. In addition, when environmental pollution becomes more and more severe, environmental monitoring is set as a mandatory condition to ensure that there are standard industrial, agricultural, forestry, and service products for people to use. The authors proceed to design an application for transmitting and receiving radio digital data to measure and display temperature and humidity values. This system has made it possible for users to visually monitor temperature and humidity data on a computer from a long distance.

Keywords: Arduino, temperature sensor, humidity sensor, radio digital data transmission.

1. Introduction

To measure environmental parameters in industrial parks, agriculture, forestry, and high-tech services, we use measuring sensors such as temperature sensors, humidity sensors, pH sensors, gas sensors, etc. Knowing important environmental parameters such as temperature, humidity, pH, etc. will allow workers to adjust their operations appropriately in order to achieve optimum performance and efficiency. The construction of these systems will be difficult when the monitoring area has a large space, a long transmission distance, a large number of sensors, and a power supply to maintain the system [1].

The acquisition and processing of these signals is done by electronic circuits using microcontroller chips. One of the most effective testing solutions before proceeding to commercial products is to use Arduino kits. The system using Arduino will help to reduce the above difficulties and allow for the simple connection of multiple sensors and remote monitoring via a digital radio data transmission system.

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2. Designed a radio digital data transmission system for measuring and displaying environmental parameters

2.1. The system's overall structure

The system of measuring and monitoring environmental parameters is designed with two parts:

Transmitter: DHT11 sensor for temperature and humidity measurement. The central processing board uses an Adruino Uno R3. NRF24L01+ module to transmit humidity and temperature data to a computer and display it on the software. The DHT11 sensor communicates with the central processing board according to the 1-Wire standard. The central board continuously reads data from the DHT11 every 1 s. This data is saved in the RAM memory of the Arduino Uno. The central processing board communicates with the NRF24L01 radio transceiver circuit according to the SPI standard. When the connection is successful, the temperature and humidity data are transmitted by the Adruino board to the NRF24L01 circuit. Here, the data is framed into bytes and modulated by the FSK method, operating in the 2.4GHz frequency band through the antenna, transmitting into space and transmitting to the receiver.

Receiver: Using the Adruino Nano Board as the board to connect, control, and transfer data to the computer. At the same time, the receiver also uses the NRF24L01 circuit to receive data through the antenna. The central processing board serves as the configuration for the temperature and humidity data collection. Then the address of the NRF24L01 circuit of the receiver and transmitter are synchronously working. Temperature and humidity data is received by the NRF24L01 circuit from the antenna, demodulated, and transmitted to the Adruino Nano central processing board according to the SPI standard. Here the data is framed and transmitted to the computer according to the UART standard.

2.2. Components of the system

- DHT11 sensor:

The DHT11 sensor is a common sensor and communicates over a single signal line with the processing circuitry. The sensor has a built-in signal preprocessor. Therefore, the data obtained is very accurate without going through any calculations [2]. It allows simultaneous measurement of the temperature and humidity of the air environment.

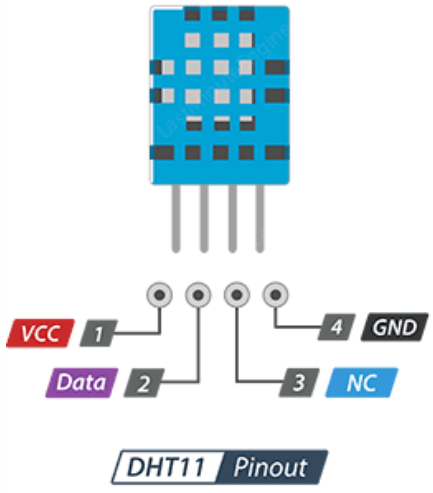

Fig.1- DHT11 sensor pinout configuration

- Soil Moisture Sensor HS000163:

A soil moisture sensor consists of 2 components: a probe and a signal processing circuit. The actual image of the sensor is shown in Figure 2. The sensor has a potentiometer to adjust the sensitivity of the D0 digital output, one LED and one LED digital output. The sensor's operation is simply that the sensor output voltages change to suit the water content of the soil. When the soil is wet, the output voltage decreases, and when the soil is dry, the output voltage increases. Threshold values for digital signals can be adjusted using potentiometer [3].

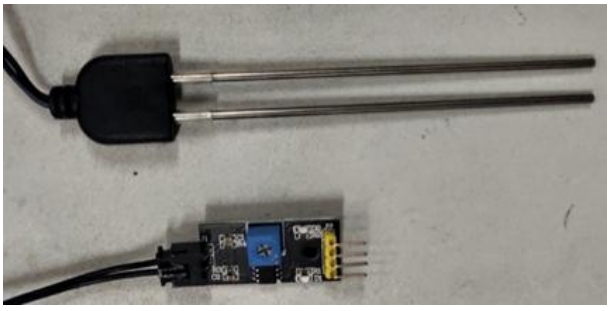

Fig.2- HS000163 Soil Moisture Sensor

- The rain sensor:

The rain sensor is made from a sheet of Bakelite or mica plastic with dimensions of 5 cm x 4 cm. On the two surfaces, there are metal conductors that are adhered with epoxy adhesive. The distance between the wires inside is about 3-5 mm.

When there is no rain, the impedance between the wires will be very high, and there will be no transmission between the wires in the sensor. When rain falls on the sensor plate, it will short circuit points A and B. Then, there will be transmission between wires [4].

Fig.3- The rain sensor

- Arduino UNO R3:

The Arduino UNO R3 is a 3rd generation Arduino UNO kit, with the ability to program complex control applications. The Arduino UNO R3 is equipped with a powerful configuration with ROM, RAM, and Flash memory types, as well as digital I/O inputs and outputs. In which many pins can output PWM signals, read analog signals, and use various communication standards such as UART, SPI, and TWI (I2C).

The Arduino UNO R3 is an integrated microcontroller based on the ATmega328P (8-bit) with an operating voltage of 5V, an operating frequency of 16MHz, 14 pins of Digital I/O (6 pins hardware PWM), 6 pins of Analog (10bit resolution), has 32 kB of flash memory for storing code (of which 0.5kB is used for the bootloader) [4].

- Arduino Nano:

The Arduino Nano is an integrated microcontroller based on the ATmega328P, with 32 pins and 8 ADC ports. The Nano board does not have a DC power jack like other Arduino boards, but instead has a mini-USB port. This port is used for both programming and serial monitoring. The attractive feature of the Arduino Nano is that it will choose the maximum power with its voltage [4].

- NRF24L01+:

It has a transceiver distance of up to 1 km, has built-in antennas on the board, is capable of transmitting 2-way signals, and easily connects to Arduino to perform radio reception and transmission at 2.4GHz.

2.3. Hardware design for the system

Based on the components of the system, the authors have built a temperature, humidity, and precipitation measurement system as shown in Figure 4 and Figure 5.

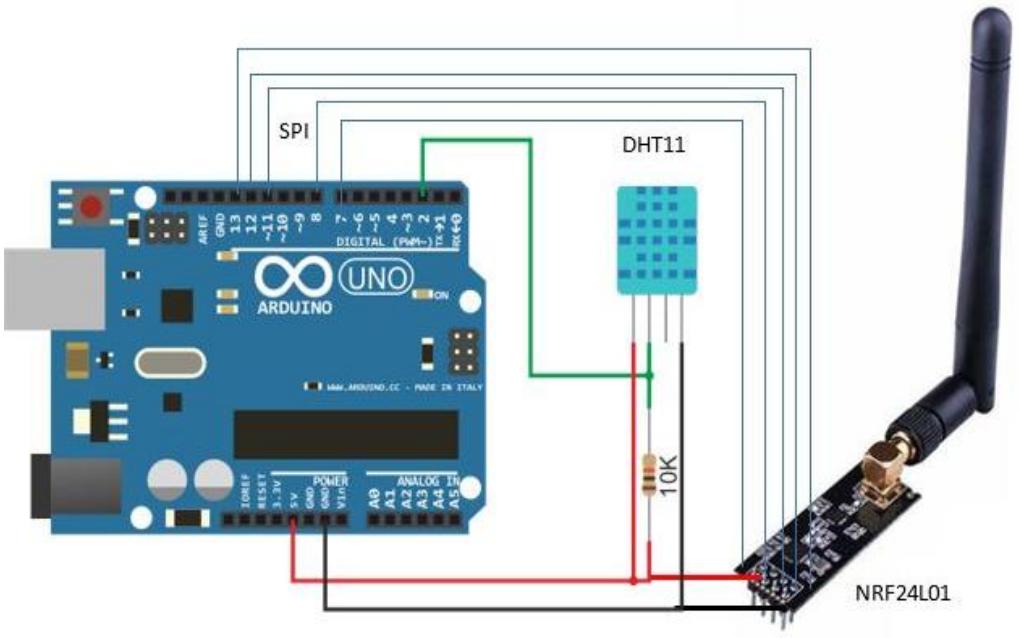

Fig.4- Transmitter side of the environmental parameter monitoring and measuring system

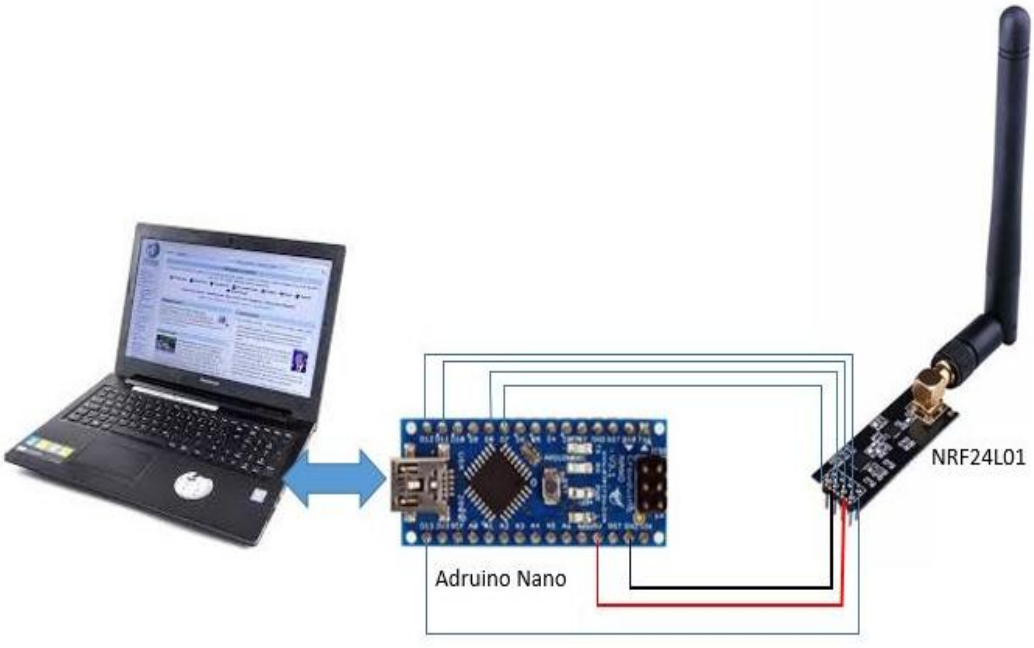

Fig.5- Receiver side of the environmental parameter monitoring and measuring system

To communicate between Arduino and DHT11 according to the 1-Wire standard, we need to connect the signal pin of DHT11 to the digital pin of the Arduino. The NRF24L01 communicates with the Arduino via the SPI protocol.

Table 1. Communication between NRF24L01 and Arduino

NRF24	Arduino
GND	GND
VCC	3.3V
CE	D9
CSN	D10
SCK	D13
MOSI	D11
MISO	D12
IRQ	Don't use

2.4. Design the display interface for system software

The software displays temperature and humidity with an interface as shown in Figure 6.

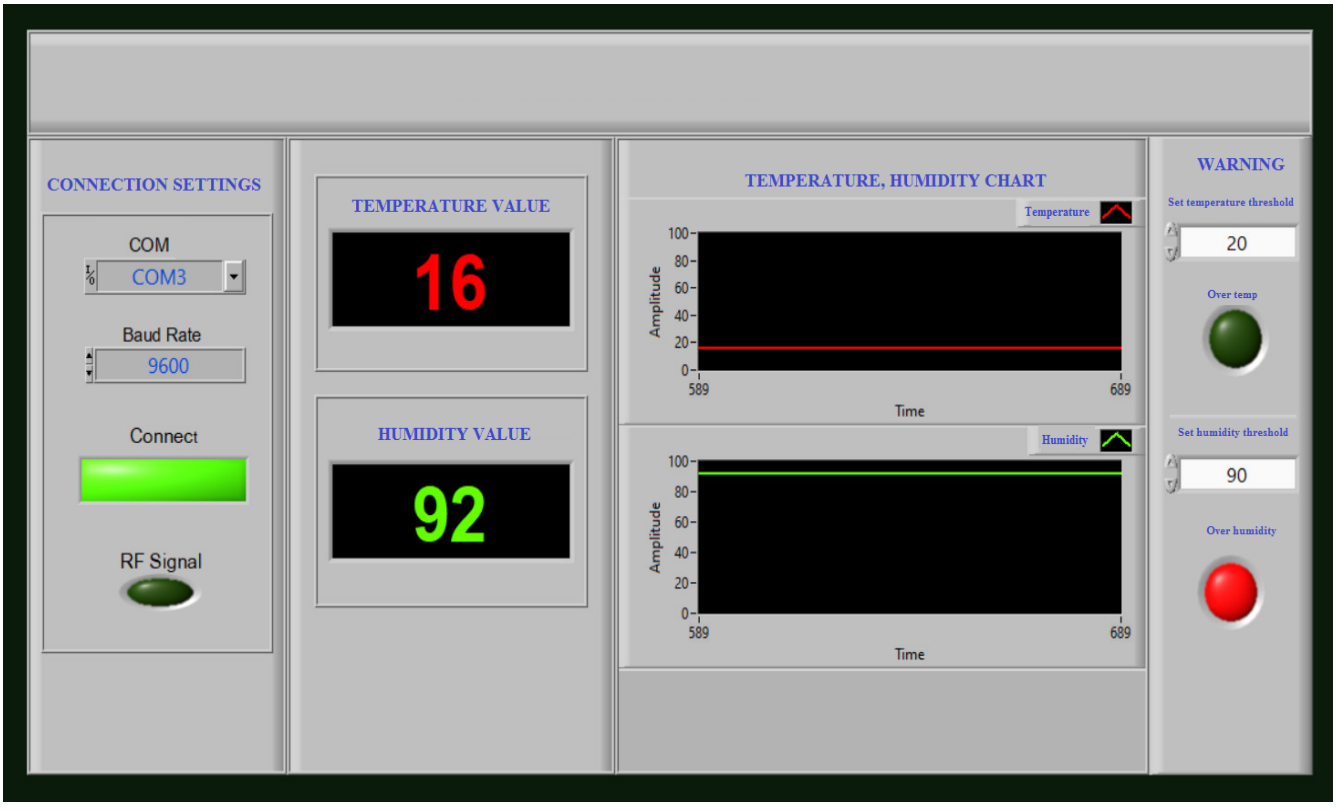

Fig.6- Software interface showing temperature and humidity measurement results

Connection settings panel: To define communication, such as choosing the connection port between the Arduino and the computer, set the Baud rate. "Connect" light to indicate the connection status between Adruino and the computer. "RF signal" light to indicate data transmission and reception status.

The panel displays temperature and humidity measurement results: To notify users of the temperature and humidity of the area being measured.

The panel displays temperature and humidity graphs over time: To track changes in temperature and humidity over time.

Alarm panel: To set temperature and humidity thresholds and notify of "overheating" or "too humid" status when temperature and humidity exceed the allowable thresholds.

In the program, the computer communicates with the Adruino Nano board according to the UART standard. The data received from the COM port includes temperature and humidity values, which are processed by the software and displayed on the software interface. This value is compared with the preset threshold level. If the threshold level is exceeded, a red light signal will be activated

The Block Diagram in LabView contains the graphical source code as in Figure 7:

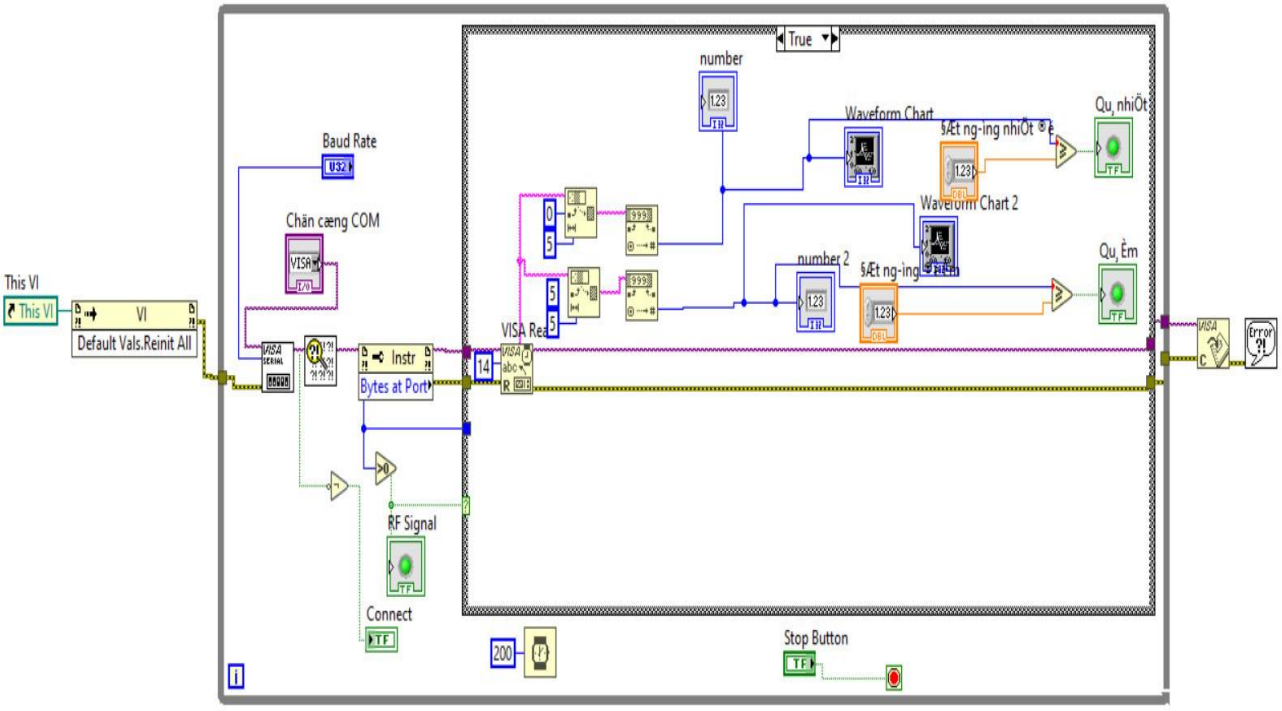

Fig.7. Software program source code

Thus, through the application written on Labview, users can easily and intuitively monitor the measured temperature and humidity values in the monitoring area with a large space and long transmission distance.

3. EVALUATION OF RESULTS

After assembling and finishing the product, the author measures the ambient temperature and humidity. The system gave the correct results according to the design requirements. The chip's processing speed is fast, stable, and accurate. The interface of the software is intuitive and easy to use.

Experimenting with changing conditions of temperature and humidity, the system responds accurately and displays it with a time chart on the software interface. Experimentally changing the distance between the transmitter and the receiver, it was found that the system can transmit data stably over a distance of 800m in the absence of obstacles.

4. CONCLUSION

Data on temperature and humidity are very important environmental parameters in the preservation and storage of equipment and goods. Based on research on the structure and operating principles of hardware devices, the author designed

an application for transmitting and receiving radio digital data, displaying temperature and humidity values in LabView software. This system has made it possible for users to visually monitor on a computer the measured values of temperature and humidity in the monitoring area with a large space and long transmission distance.

ACKNOWLEDGEMENT

This work is supported by: Department of Information Technology, Faculty of General Education, University of Labour and Social Affairs in Hanoi Vietnam. Faculty of Fundamental Technics, AD-AF Academy of Viet Nam.

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