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Design of Environmental Monitoring System for Power Distribution Room

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ABSTRACT

In order to meet the demand of unmanned management of distribution station room, we design the automatic environmental monitoring system of distribution station room. The system includes host, sensor module and relay output module. The host adopts STM32 microcontroller as the main control chip; the sensor module includes temperature, humidity, noise, human infrared, smoke and flooding monitoring functions, and the monitoring data is transmitted to the host through RS485 communication, and the host can upload to the cloud platform through Ethernet or 4G communication. The host computer extends the relay output module, which can be connected to external environmental control equipment. Using fuzzy control technology to regulate the temperature in the distribution station room, using MATLAB software simulation, the results show that: the control system response time is 4s, overshoot is less than 5%, can quickly and effectively regulate the temperature. The field test shows that the system operates stably and the cloud platform can meet the demand of information management and automatic monitoring of the distribution station room.

Smart grid is the future development trend of power grid, and intelligent and unmanned represents the future development form of distribution station room management. The distribution station room is the smallest unit and data source of the distribution network, and is the key to the intelligence of the last kilometer of the ubiquitous power IOT distribution network [1-2]. At present, most of the distribution station rooms arrange dedicated personnel to manage the depot, and all kinds of information are recorded by hand, which leads to more problems. With the development and promotion of intelligent and automated technologies, more and more power grid enterprises require unmanned management of distribution station rooms [3-5]. Efficient management of the distribution station room is a key factor affecting the stable production and operation of the power grid enterprises [6]. In order to meet the demand of unmanned management of distribution station room, based on sensor technology, communication technology, embedded technology and cloud platform, the environmental monitoring system of distribution station room is designed to provide technical guarantee for safe and stable operation of distribution station room.

1. Monitoring scheme design

The design scheme of the environmental monitoring system is shown in Figure 1. The system consists of sensor module, host and output. The sensor module is connected to the host and transmits data through RS485 bus; meanwhile, the monitoring data is transmitted to the cloud platform through 4G communication; the output can be connected to an external environmental regulation and control device. The system supports GPRS, Ethernet, RS485 bus and other ways to upload data, and sensors can be added according to the type of environmental data required.

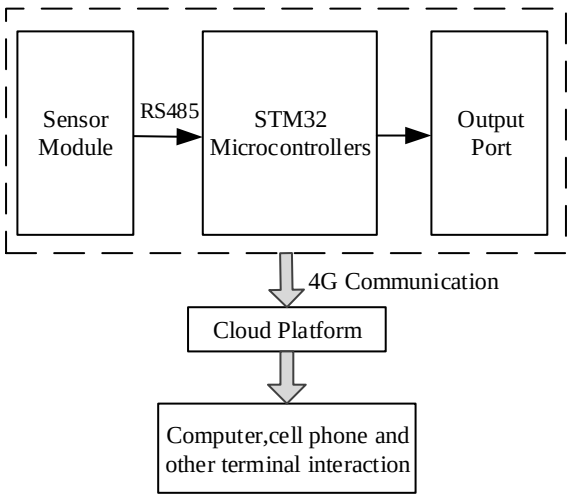

Fig. 1. Environmental monitoring system design scheme.

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2. Hardware system design and data communication

2.1 Hardware System Design

The hardware structure of the environmental monitoring system is shown in Figure 2. The host computer is based on STM32F072C8T6, the STM 32 microcontroller, which has ARM Cortex-M3 core and can better meet the demand for time-sharing processing and analysis of multi-channel data [7]. The sensor module includes temperature and humidity sensors, smoke sensors, noise sensors, and human infrared sensors, and the data collected by each sensor is transmitted to the host computer in turn through the RS485 communication module. The outputs are equipped with relay modules that can be connected to thermostats, alarms, and other devices, thus realizing automatic environmental monitoring and control functions. The host front screen displays the parameters, and the parameters can be set through remote terminals such as remote control, cell phone or computer. The main control selects metal shell, dustproof, anti-static and anti-interference ability. The system comes with voltage monitoring and has the function of automatic data caching after power failure and automatic data uploading after power on.

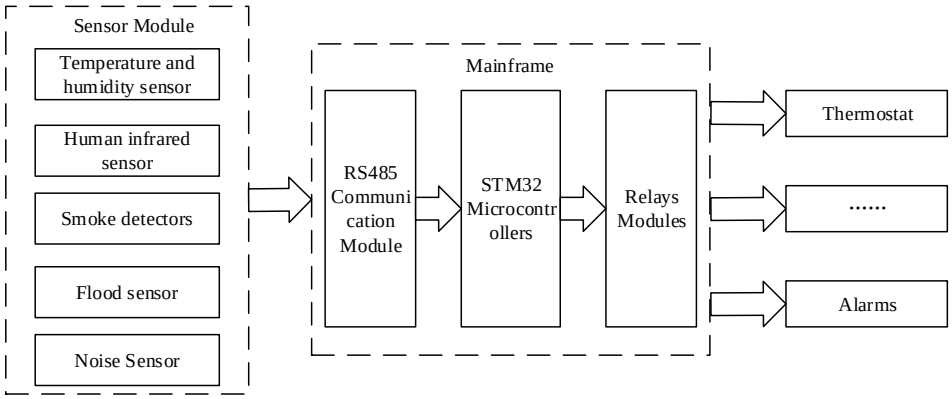

Fig. 2. Hardware structure of environmental monitoring system.

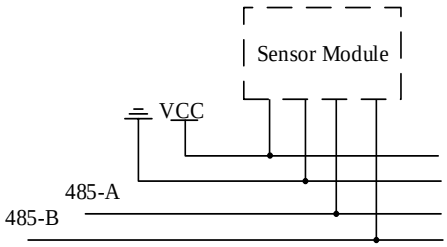

Fig. 3. Sensor circuit.

2.2 Sensor Application

The sensors in the sensor module are connected to the host computer using the RS485 bus form, and the communication protocols are MODBUS -RTU, and the connection principle is shown in Figure 3.

As shown in Figure 4, each sensor in the sensor module is connected in parallel with the host computer to form the environmental monitoring system of the distribution station room, and the main parameters of each sensor are as follows:

(1) Temperature and humidity sensor. Real-time monitoring of temperature and humidity changes. Temperature monitoring range is -40 ~ 100 ℃, the measurement error is ± 0.2 ℃; humidity monitoring range is 0 ~ 100% RH; the measurement error is ± 3%. The operating voltage is 12~24VDC.

(2) Human infrared sensor. Sensing whether someone enters the area and alarm. Sensing blocking time of 2.5S; after the sensing module is powered on, it takes 1min to initialize, during this period the module interval output 0-3 times, and after 1min it enters standby state.

(3) Water flooding sensor. Positioning type water leakage alarm equipment, can accurately display the location of the fault, to achieve rapid troubleshooting positioning. Configured with 2-way flood sensor input port and 2-way relay output port.

(4) Noise sensor. Monitor the station room for abnormal noise. The sensor has signal sampling and amplification, drift zero and noise compensation functions. Operating temperature: -40 ~ 85 ° C; working humidity: 0 ~ 100% RH; power supply voltage: 6V ~ 24VDC; measurement range: 30 ~ 130 dB; frequency range: 20Hz ~ 12.5kHz.

(5) Smoke sensor. Monitor whether a fire occurs. Using photoelectric smoke sensor devices, power supply: 10 ~ 30V DC; alarm power consumption: 0.7W; static power consumption: 0.12W; alarm sound: ≥ 80dB; smoke sensitivity: 1.06 ± 0.26% FT.

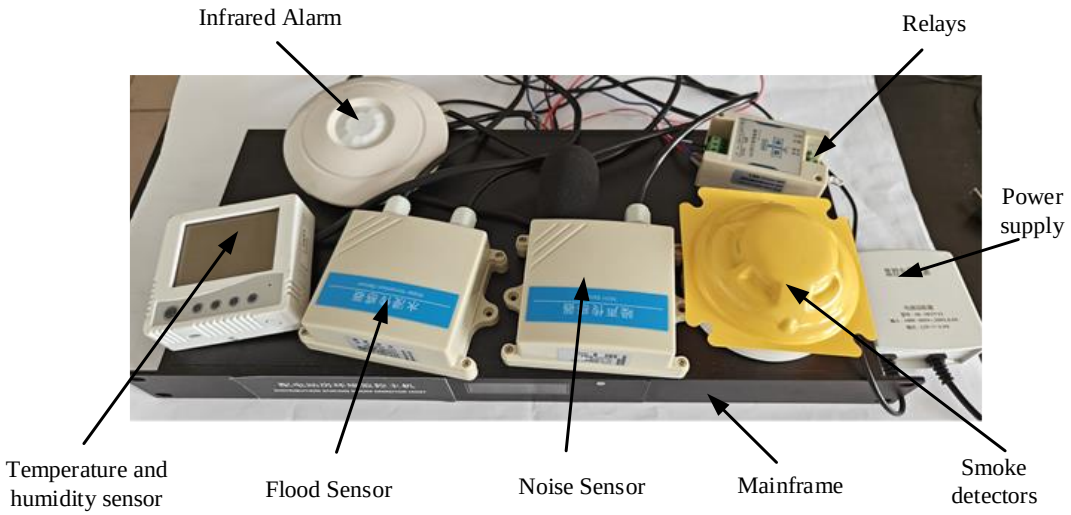

Fig. 4. Environmental monitoring system of distribution station room.

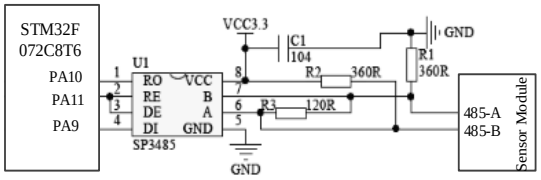

Fig. 5. RS485 communication circuit schematic

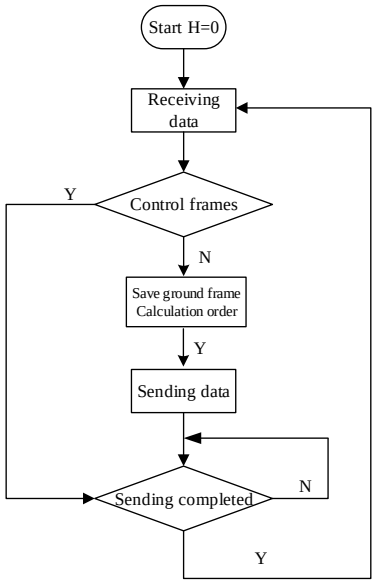

Fig. 6. Data communication flow.

2.3 RS485 communication

Figure 5 shows the principle of RS485 communication circuit, according to the RS485 bus standard, the digital signal is transmitted by differential transmission, which can effectively reduce noise signal interference. To ensure that each sensor collects data accurately and responds quickly, the order of sensor upload data is determined by comparing the communication address with the bus device address information data to realize the active sending of data to the bus [8].

The basic parameters of the bus communication are: baud rate 2400 bps, sensor return data frame length 11 bytes, upload a complete data frame about 50 ms. Each sensor address information is compared with the received bus device address information control frame sent by the host one by one, so as to determine the data sending order of each sensor; if the sensor address information is not found, it is treated as a new access sensor. Each time the sensor receives the last 1 byte of the host data, the timer clears 0. Assuming that the sensor sends data in order n, the data is actively uploaded after the timer has timed to n × 50 ms. The sensor completes 1 data communication flow as shown in Figure 6.

2.4 Relay Output Ports

The host relay module is equipped with 4 sets of output ports, and the environmental regulation equipment is connected to the relay output ports, so as to realize the automatic environmental regulation in the distribution station room. In this paper, according to the actual needs of the distribution station room, the temperature in the station room is automatically regulated, where the T1 port is connected to the STM32F072C8T6 microcontroller data output port, and the relay output port is connected to the thermostat, and the relay module circuit is shown in Figure 7.

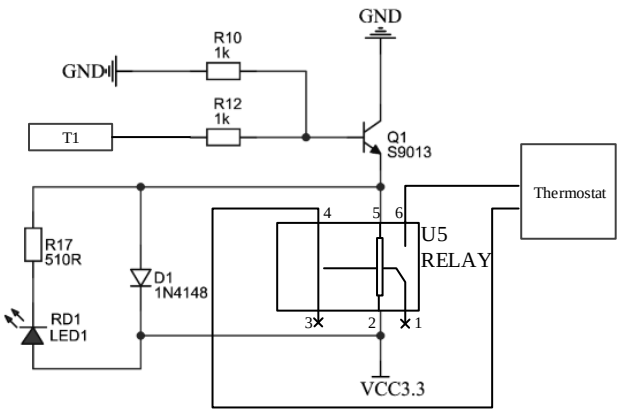

Fig. 7. Relay circuit.

2.5 Temperature fuzzy control

The distribution station room environment has high temperature requirements, and the ambient temperature control has a large delay, nonlinear and other characteristics, the use of fuzzy control methods can effectively improve the accuracy of ambient temperature regulation [9-10]. Set the appropriate temperature value, through the fuzzy control method, control the thermostat start-stop state, and then regulate the ambient temperature in the distribution station room, while using the sensor real-time monitoring, the control process to form a closed loop, so as to accurately control the temperature in the station room. The temperature fuzzy control process is shown in Figure 8.

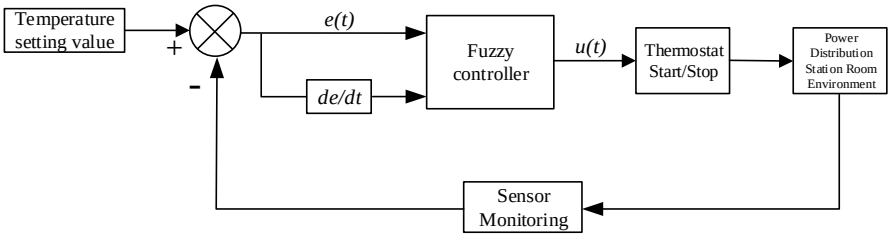

Fig. 8. Temperature fuzzy control process.

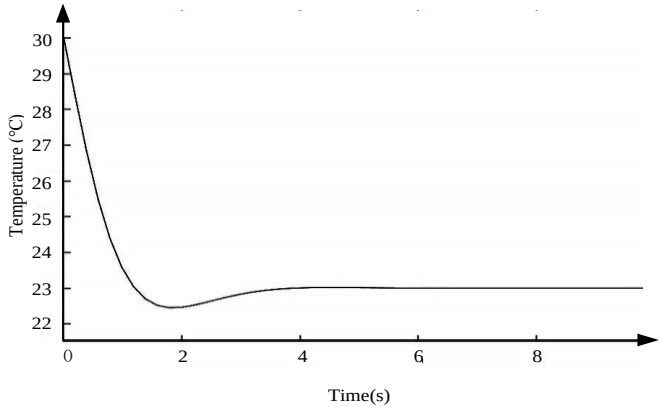

Fig. 9. Temperature fuzzy control effect.

Two-dimensional fuzzy control is used with input variables of ambient temperature error e and error rate of change de/dt, and output variable u is thermostat start/stop for fast cooling; the input and output variables are edited in combination with the control accuracy and system requirements, which contain the theoretical domain of the determined variables, the composite function of the determined affiliation and its related parameters. e, de/dt, and u have fuzzy theoretical domains in the order of [0, 40], [-0.05, 0], [0.2, 0.5], the fuzzy subsets are {NB, NM, NS, Z, PS, PB, PM}, and the affiliation function is triangular. The fuzzy control system is constructed using Matlab software, assuming the current ambient temperature is 30°C and the ambient temperature setting value is 23°C. Under the setting

conditions, the system simulation curve is shown in Fig. 9, and the response time of this control system is 4s, and the overshoot does not exceed 5%.

3. Cloud platform application and testing

To realize remote unmanned monitoring of the distribution room environment, the host computer can upload the collected data to the cloud platform in real time through Ethernet or 4G communication, and the user can access the cloud platform using the account and password according to the set URL [11]. The display interface of the cloud platform is shown in Figure 10, and the display content includes: the geographic location of the host, the real-time collected data information of each sensor and the status of the relay control equipment.

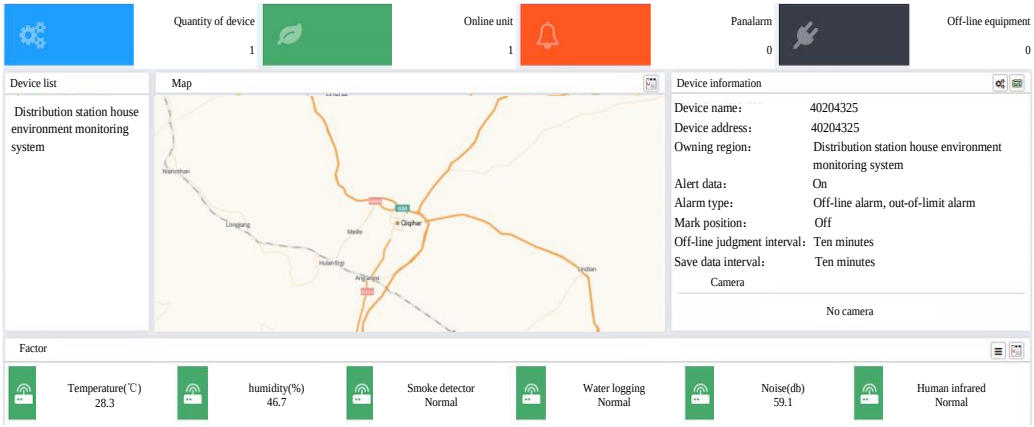

Fig. 10. Cloud platform display interface

Access to the cloud platform through a computer or cell phone terminal allows real-time access to data including temperature, humidity, flooding, noise, etc. Except for temperature, humidity and noise, other sensor monitoring are displayed as normal or abnormal. 8:00 to 13:40 on May 18, 2023, data are uploaded through the host every 10min interval, the temperature set value is 27℃, humidity is not set, Figure 11 shows the temperature and humidity monitoring data curve. The curve shows that the temperature can be stabilized between 27℃ and 27.5℃ by adjustment, within the error allowed.

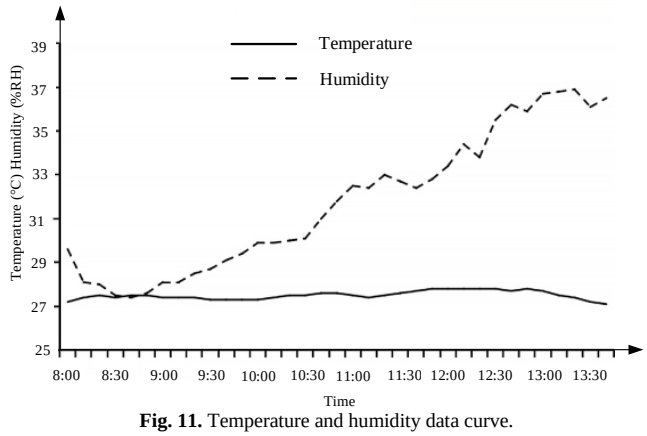

Fig. 11. Temperature and humidity data curve.

4. Conclusion

The STM32F072C8T6 is used as the core design host of the distribution room environment monitoring system, and the RS485 bus is used to connect the sensor module and configure the relay output module; the fuzzy control method is used to precisely regulate the environment temperature in the distribution room, and the MATLAB software is used to simulate the control system. After field testing, the system can achieve the following functions:

(1) real-time monitoring of temperature, humidity, smoke, noise, human infrared, water flooding and other data;

(2) Configuration of relay output module, which can be connected to external environmental regulation and control equipment or alarm equipment;

(3) The cloud platform can monitor the data in real time, and can realize remote control.

The system can monitor the data in real time and accurately, and provide technical support for the unmanned management of the distribution station room.

Acknowledgements

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