CENTRALIZED MONITORING AND MANAGEMENT SYSTEM FOR COMMUNICATION STATIONS

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ABSTRACT

This paper presents a centralized monitoring and management system for communication stations in communication units. The system includes on-site monitoring and alert device located at communication stations and centralized monitoring and management software at the operating center. To ensure data security and optimize costs during system operation, power parameters and working environment conditions such as temperature, air humidity, light are measured and sent to the centralized monitoring and management center via the military data transmission network. The centralized monitoring and management system for communication stations was designed, manufactured and tested at Brigade 139, Communications Command. Device located at the communication stations works stably for a long time, gives warning signals immediately when there are problems with power, temperature, and humidity. The monitoring and management software visually displays measured data, is designed simple, convenient for users and is built on a server and clients mechanism, allowing multiple units monitor and manage communication stations at the same time.

HỆ THỐNG GIÁM SÁT, QUẢN LÝ TẬP TRUNG TRẠM THÔNG TIN

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TỪ KHÓA

Trạm thông tin
Giám sát
Quản lý tập trung
Nguồn điện
Điều kiện môi trường

TÓM TẮT

Bài báo này trình bày về hệ thống giám sát, quản lý tập trung cho các trạm thông tin trong các đơn vị thông tin. Hệ thống được thiết kế gồm thiết bị giám sát, cảnh báo tại chỗ đặt tại các trạm thông tin và phần mềm giám sát, quản lý tập trung tại trung tâm điều hành. Để đảm bảo tính bảo mật cho dữ liệu và tối ưu chi phí trong quá trình vận hành hệ thống, các tham số về nguồn điện và điều kiện môi trường làm việc như nhiệt độ, độ ẩm không khí, ánh sáng sau khi được đo tại các trạm thông tin sẽ được gửi về trung tâm giám sát, quản lý tập trung qua mạng truyền số liệu quân sự. Hệ thống giám sát, quản lý tập trung cho các trạm thông tin được thiết kế, chế tạo và thử nghiệm tại Lữ đoàn 139, Binh chủng Thông tin liên lạc. Thiết bị đặt tại trạm thông tin hoạt động ổn định trong thời gian dài, kịp thời đưa ra các cảnh báo khi có sự cố về nguồn điện, nhiệt độ, độ ẩm. Phần mềm giám sát, quản lý hiển thị trực quan các số liệu đo được, được thiết kế đơn giản, thuận tiện cho người sử dụng và được xây dựng theo cơ chế máy chủ và các máy con, cho phép đồng thời trung tâm điều hành và các đơn vị cấp dưới cùng giám sát hệ thống.

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1. Introduction

Communication plays an important role, affect directly to outcome of battles in modern warfare [1]. Therefore, ensuring smooth and continuous communication is the central task of communication units in the army. Communication stations are the backbone of the data transmission communication system with many modern communication equipments, ensuring stable data transmission from the tactical to strategic. With the increasing role of communication stations in the military communication network, the requirements for reliable and stable operation of communication stations are also increasingly high. Once the communication stations have been installed and put into operation, the power and environmental conditions (temperature, air humidity) become the main factors that directly affect the longevity and quality of equipments in the station. Communications may be degraded or interrupted when the power system has a problem or when communication equipments work in high temperature and humidity conditions for long time. As a result, it is necessary to promptly detect and fix problems in the power and working environment conditions must always stay stable in authorized range.

Currently, at communication stations, power devices have been integrated with the ability to provide warnings to on-duty staff when problems occur (loss of alternating current (AC) power or reduced direct current (DC) voltage) and it has a device to measure air temperature and humidity. However, these devices only indicate the measured value without the ability to give warnings when the measured results are not within the reliable operating range. In particular, the monitoring and measurement of parameters is only carried out directly at communication stations; there is not any remote monitoring system for communication stations in communication units in the army. Thereby, the urgent requirement is to design a centralized monitoring and management system for communication stations to have both on-site and remote monitoring and warning capabilities. This helps promptly detect incidents, provide early warnings to communication stations, and it is especially meaningful for communication stations located in regularly hot areas. Research [2] – [6] demonstrates the effectiveness of the base station monitoring system in several ways: optimization of energy resources, early problem detection and informed decision-making. A monitoring system that provides power and temperature warnings for mobile base stations is presented in [7]. Alerts are sent to the station supervisor via the cellular network. However, this solution is not capable of centralized managing multiple base stations. Research [8] – [11] overcomes this limitation, the power parameters and environmental conditions of the base station are centrally managed by the Wifi network [8] – [10] and LORA [11]. However, data transmitted via wifi network is not suitable for high security requirements in military environment, and this solution requires additional funding to maintain during the operation. Meanwhile, the LORA network is only suitable for monitoring and managing within a narrow area such as the campus of a military unit, but is not suitable for monitoring and managing many communication stations that are not concentrated.

This paper proposes a centralized monitoring and management system for communication stations in communication units via the military data transmission network available at the stations. AC, DC powers, temperature, humidity, and light in the communication station are automatically monitored and measured, promptly giving on-site warnings by lights, buzzer, mobile networks, and remotely on software which is installed on the server computer at the operating center and the client computers at the communication units. This paper is organized as follows. Section 2 introduces the proposed centralized monitoring and management system for communication station. Section 3 shows the experimental results followed by conclusions in Section 4.

2. Proposed centralized monitoring and management system for communication stations

2.1. Layout of power in communication station

Power is a particularly important parameter in communication stations, directly affecting the regular working status of the stations. Figure 1 demonstrates a typical power system diagram in a Brigade communication station. The power supply system involves two P4-01 CT power supplies sharing a common AC input source to create a DC voltage between 43 and 58 VDC when charging the battery and 53.5 ± 0.5 VDC when unloading. The DC output voltage of the P4-01 CT power supplies is used to supply terminal devices that use DC power. At the same time, this DC output is connected in parallel with the battery to charge the battery when there is input AC power and to supply the terminal devices when AC power is lost. In addition, the output of the first P4-01 CT power supply is also used as input to the Inverter to create a voltage of 220 VAC for terminal devices using AC power.

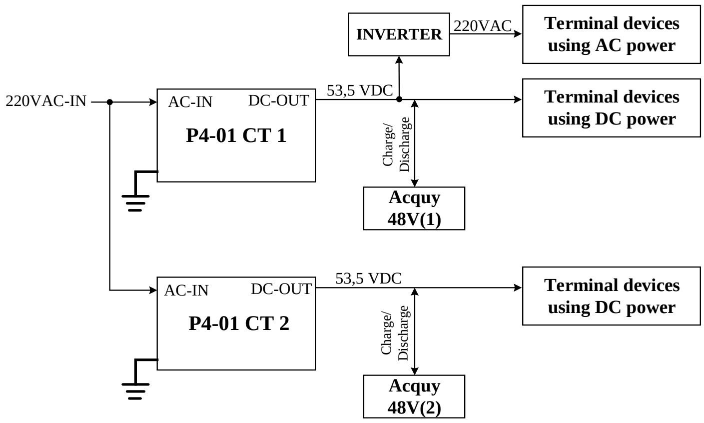

Figure 1. *Layout of typical power system in communication station*

With the power system arranged as shown in Figure 1, it will ensure high power redundancy for equipments in communication station. These powers all have on-site warnings through displaying light and buzzer. However, with unmanned communication stations, on-site warnings are not effective, problems cannot be detected and handled promptly. Consequence, the battery can be completely discharged, causing power loss and communication interruption. Therefore, in addition to on-site warnings, communication stations need to design a circuit to measure DC power and check AC power, after that sending measured data to the operating center for remote monitoring and management.

2.2. Architecture of proposed system

Figure 2 presents the architecture of the centralized monitoring and management system for communication stations. The system is divided into two parts: device located at stations and centralized monitoring software installed on computers.

At communication stations, the device uses temperature, humidity, and light sensors to automatically measure environmental condition parameters, automatically monitor AC and DC power to provide on-site warning, and at the same time send measurement results and warnings to the operating center. Here, a centralized warning, monitoring, and management software is built. The software has the function of receiving measurement parameters and displaying them on the computer screen in the form of statistical charts to make it simple and convenient for users to monitor, manage. Communication stations are connected to operating center by military LAN. The centralized monitoring and management system operates based on a server and clients mechanism. In particular, the computer located at the operating center will act as the server and computers located at different locations in the military LAN will act as clients. Data collected and displayed on the software of client computers is similar to that on the server computer. In other words, the centralized monitoring and management software on the client computer is a replica of the server. The mobile network is employed to send warning messages when a problem occurs.

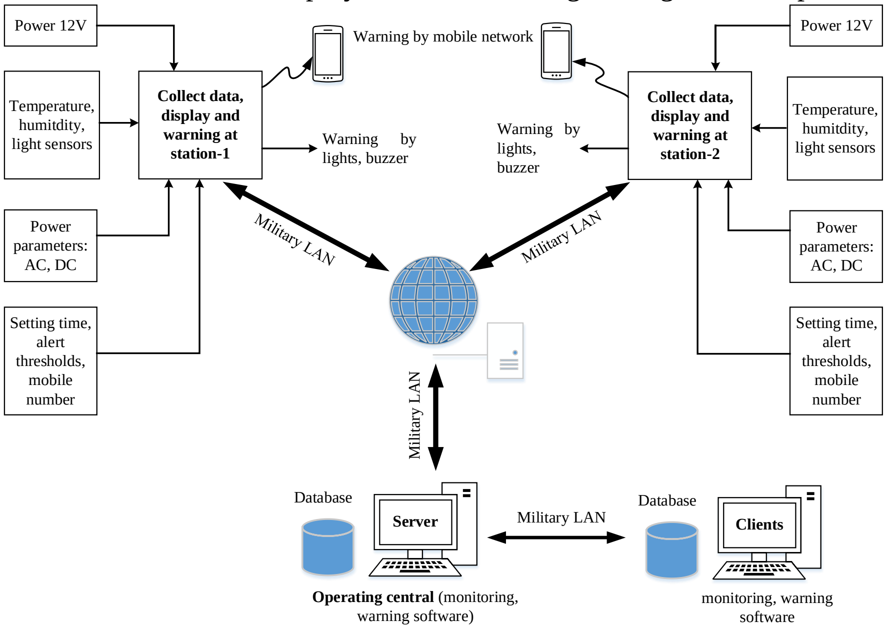

Figure 2. *Architecture of the centralized monitoring and management system for communication stations*

2.3. Hardware implementation

Figure 3 illustrates the block diagram of monitoring and warning device located at communication stations. To respond fast to problems, the paper uses Atmega128 as the device's central processing chip. The circuit operates with a 5 VDC power supply, the circuit gets analog input signals from the voltage divider circuit and the temperature and humidity sensor (using DHT-22) and digital input signals from the AC check circuit, light sensor (using photodiode), buttons and real-time clock (using DS1307). Buttons are utilized to set time parameters, warning thresholds for DC voltage, temperature, humidity and phone number. The central processing circuit sents data over the mobile network using the SIM 800a module and over the military LAN using the RS232 to Ethernet conversion module USR-TCP232-302. In which, the mobile network will immediately send an incident warning signal to the person directly managing the station, while the military LAN will send measurement and warning data from the station to the centralized monitoring and management software at the operating central. The periodic data sending time is determined from clock provided by the DS1307 module. The circuit displays working status and measurement parameters of voltage, temperature, and humidity on a 20x4 LCD, providing on-site warning signals with LED and buzzer when a problem occurs.

As mentioned above, the power is a particularly important parameter, so in this section, the paper will present the detailed design for the circuits related to the power. The communication station includes two AC power: the input AC (AC1) and the AC from the output of the Inverter (AC2), two output DC powers from two P4-01 CT power supplies. Therefore, the device is designed to check the status of two AC powers and measure the voltage value of two DC powers. The AC power status check circuit is designed based on the AC Optocoupler optical isolation technique (Figure 4). The input of the circuit is an AC signal, the power supply to the circuit is 5V1 taken from the battery. When there is AC power, the AC check circuit will generate a low level signal, i.e. KT-AC1 = 0 (KT-AC2 = 0), conversely when AC power is lost, KT-AC1 = 5V (KT-AC2 = 5V). The KT-AC1 and KT-AC2 signals are fed to the ULN2803, the outputs of the

ULN2803 (AC1 and AC2) are fed into the input pins of the Atmega 128 central processing chip to determine the status of the AC sources. If these input pins are low logic, the central processing circuit will decide that AC power is lost and vice versa.

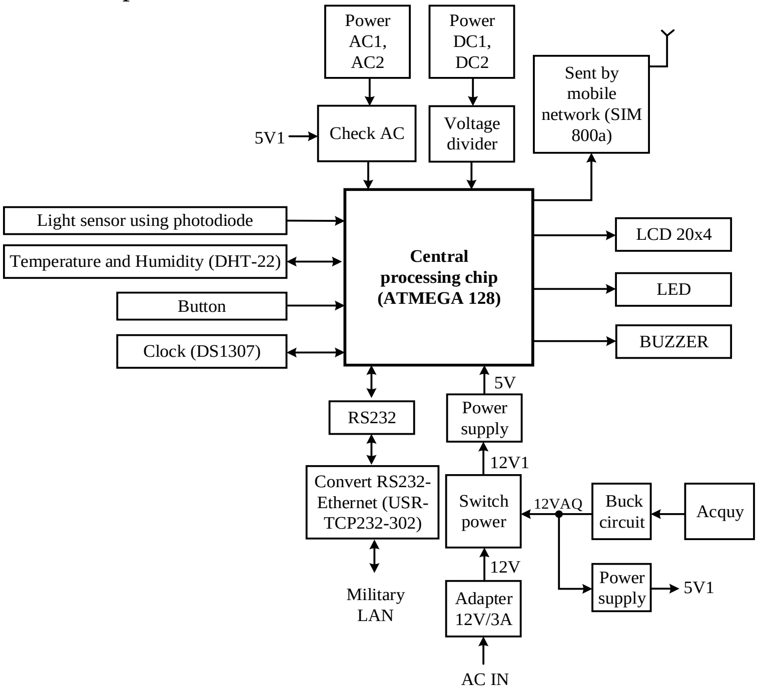

Figure 3. *Block diagram of monitoring, warning device at station*

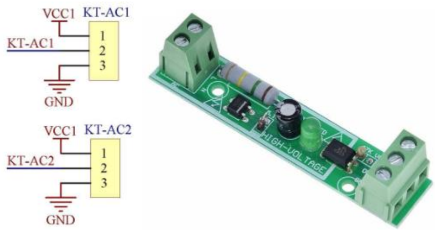

Figure 4. *AC check circuit*

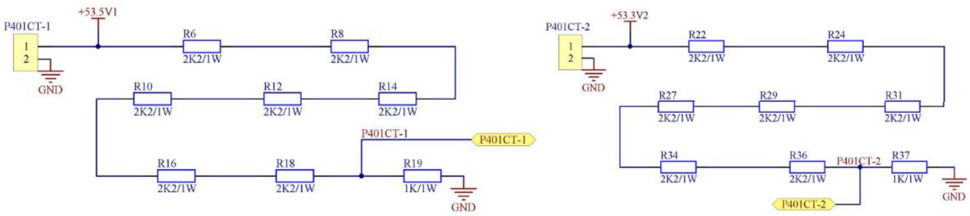

Figure 5. *DC measured circuit*

The device uses the ADC ports of the Atmega 128 microprocessor to measure DC voltage from the output of two P4-01 CT power supplies. However, the ADC of the processor chip works with an input signal less than 5V, so before applying the DC voltage to be measured into the ADC pin on the chip, it is necessary to lower the DC voltage to below 5V. The most convenient and simple way is to use a series resistor network as shown in Figure 5.

To ensure measurement accuracy and small circuit size, six 2.2 kΩ/1W resistors and one 1 kΩ resistor in series are used to step down the voltage. Then the voltage applied to the ADC pin of the microprocessor chip will be calculated by:

$$V_{in} \approx \frac{V_{P4-01CT}}{16.4} \tag{1}$$

Based on the value read from the 10-bit ADC of Atmega 128, voltage value is measured.

An important requirement is that the device must ensure stable operation even mains AC power is lost. Therefore, an automatic power switching circuit is designed as shown in Figure 6.

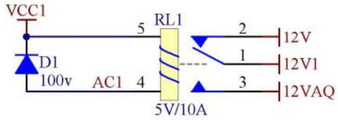

Figure 6. *Automatic power switching circuit*

The circuit uses a 5V/10A relay to perform automatic power switching. When there is mains AC power, the circuit will select the input 12V voltage (generated from the 12V/3A adapter) for the output (12V1 = 12V). Conversely, the AC1 power check circuit will generate a high level KT-AC1 signal, which is passed through the ULN2803 to create a low level AC1 signal. Next, the AC1 signal is applied to the relay coil to activate the relay, then the circuit selects the 12V voltage generated from the battery for output (12V1 = 12VAQ).

2.4. Software implementation

2.4.1. Control program for central processing chip

A control software program for the Atmega128 central processor was built to monitor and measure power parameters and working environment conditions, issue on-site warnings and send measurement data and warnings to the operating center. Figure 7 presents the algorithm flow chart of the control program.

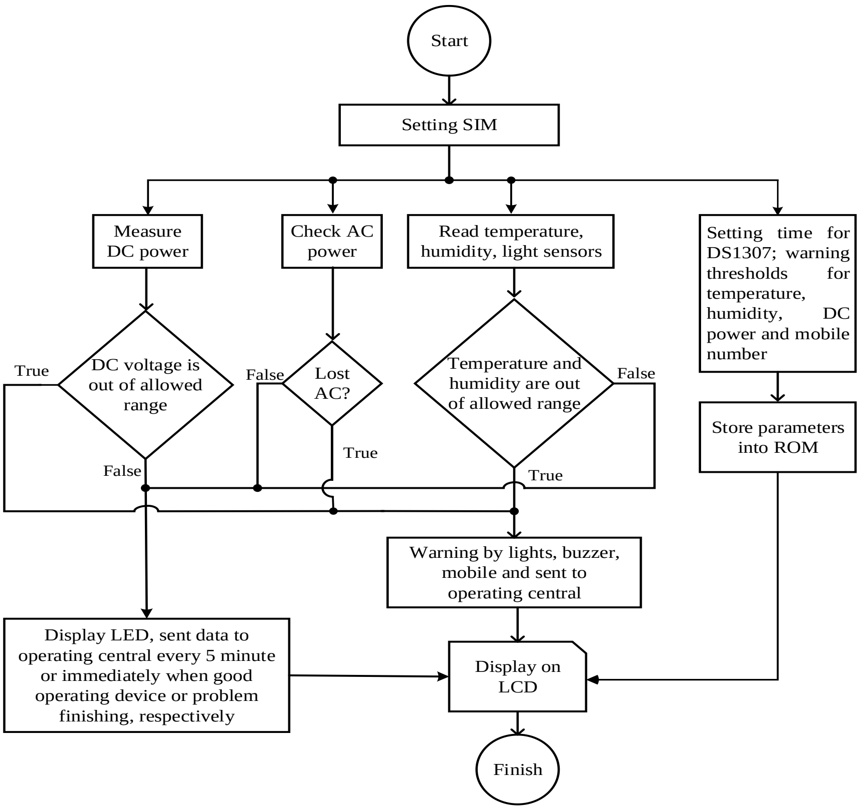

Figure 7. *The algorithm flow chart of central procesing chip*

First, the microprocessor will initialize the working state for the mobile SIM. The circuit then reads the temperature, humidity, and light sensors, checks the status of the AC power, and measures the DC voltage of the P4-01 CT power supplies. The program has two working modes: good and warning. In particular, the warning state is given when the measured temperature, humidity, and DC voltage values are not within the pre-set good working range or the AC power is lost. At that time, warning signals are given immediately by lights, buzzer, and mobile. In good operating mode, the device will display the green light status and send data to the operating center for monitoring every 5 minutes. Power parameters and environmental conditions are sent immediately to the operating center when the problem occurs and ends for timely handling. Besides, users can set warning thresholds and change the phone number to send warnings by pressing the buttons in front of device. The set warning thresholds are also sent to the operating center so that the centralized monitoring and management program can update the thresholds to decide the status of the parameters.

2.4.2. Centralized monitoring and management software

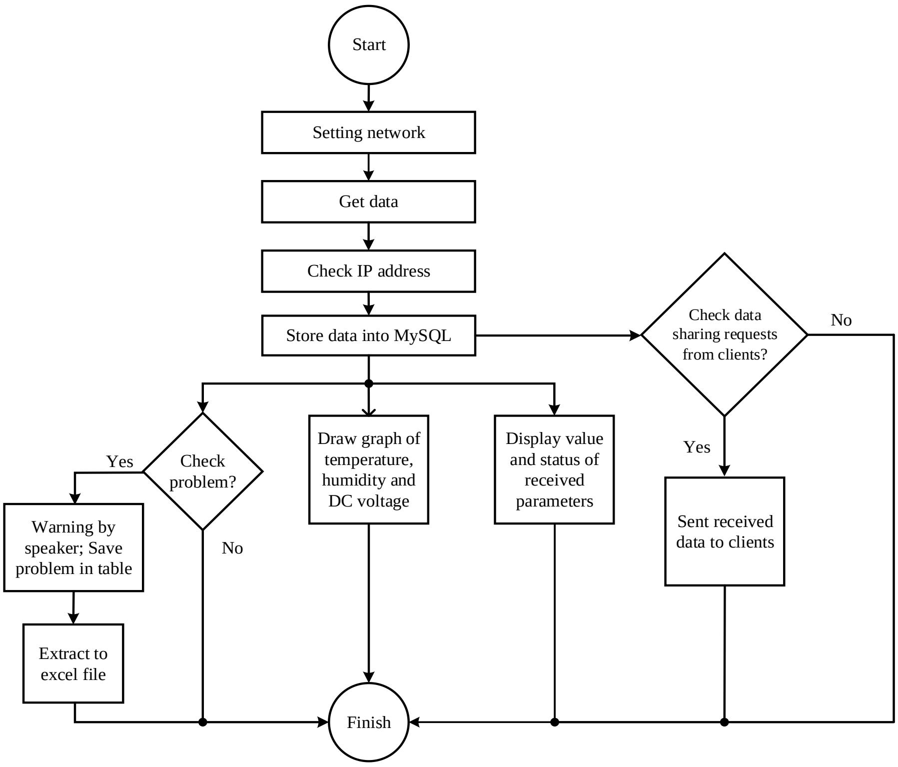

Figure 8. *The algorithm flow chart of centralized monitoring, management software*

The software is designed in the Python language [12] according to the server-clients principle to permit multiple computers to simultaneously monitor and manage communication stations. Figure 8 shows the algorithm flow chart of the centralized monitoring and management program at the operating center. All communication stations are connected to transmit data directly to the operating center. Here, the program will check the IP address of the received data packet to store data to MySQL for the corresponding stations, and also check data sharing requests from client computers. If there is a request to share data from the client, the program will send the received data from the stations to the program's database on the client for processing. Data processing process of the client is similar to that on the server. Next, the software will display the value and status of the parameters and draw graphs for the received data for the corresponding communication stations. At the same time, based on the received data, the software will compare with the warning thresholds to display the warning status, gives warning signal by speaker and save problems in tables according to occurrence and end time. From there, users can choose any time to retrieve problems and export them to Excel for monitoring, management and reporting.

3. Experiment results and discussion

To verify the operation of the proposed system, the author manufactured two monitoring and warning devices for two communication stations.

Figure 9. *Image of two on-site monitoring and warning devices*

The on-site monitoring and warning devices are designed with a mechanical shell on AutoCad software, made of corrugated iron, coated with electrostatic paint. The device has dimensions (length x width x height) of (26 x 16.5 x 10.5) cm, weight 2.5 kg. The fabricated products of the two devices are shown in Figure 9. Within the framework of the paper, the author focuses on presenting test results for AC1 power and temperature and humidity problems.

First, the alarm thresholds for temperature, humidity, DC voltage and the phone number are set as shown in Figure 10. Good operating ranges of environmental temperature and humidity are set according to regulation 9878 [13], from (20 ÷ 25)^{0}C for temperature and (40 ÷ 80) % for humidity, while the DC voltage range is set according to the technical document of P4-01 CT, low voltage level 1 is 47 V, level 2 is 48 V and high level is 58.5 V .

(a) (b) (c)

Figure 10. *Setting parameters of device:(a) teparature, humidity; (b) DC voltage; (c) phone number*

When AC1 power lost, the device automatically switches to using battery power, the status is displayed on the LCD screen with AC1 power changing from ON to OFF, the light turns red and the buzzer sounds, and at the same time a messages are sent to the established phone number (Figure 11). When AC1 power is restored, the device automatically switches from using battery power to AC power, the status of AC1 power changes from OFF to ON, the light changes from red to green and a message that notifies the end of the problem is also sent (Figure 12). As a result, with the automatic power switching circuit design solution, the device ensures stable operation in case of AC power failure.

Figure 11. *Respond of device when AC1 power lost*

Figure 12. *Respond of device when AC power is restore*

Figure 13 and Figure 14 demonstrate the device's response when temperature and humidity problems occur and when the problem ends, respectively. Impact the temperature and humidity sensor to change the temperature and humidity values that the sensor measures. At this time, the measured temperature and humidity values are 26^0C and 100% respectively. These values are greater than the set threshold (25^0C for temperature, 80% for humidity), so the device will given a warning signal. After a period of time, the measured temperature and humidity values (temperature 24.1^0C, humidity 77.2%) return to the good operating range, the device returns to normal operating state.

Figure 13. *Respond of device when occuring temparature and humidity problem*

Figure 14. *Respond of device when ending temparature and humidity problem*

The main screen interface of the centralized monitoring and management software is presented in Figure 15. The interface is designed to be simple, convenient for users, and has the ability to expand the number of monitoring stations. At each station there is a button to indicate the station's operating status. The system is monitoring two stations A70 and A45 and the power parameters and environmental conditions in these two stations are good, so the status buttons on these two stations are green.

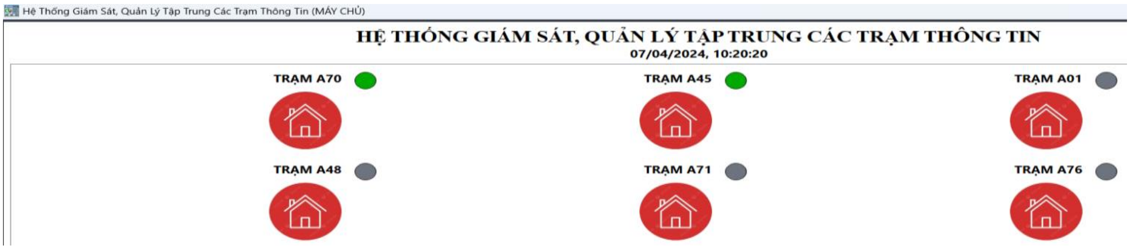

Figure 15. *Interface of centralized monitoring and management software*

Figure 16 shows the interface displaying parameters of station A45 when AC1 power is on and off. For each station, the software will display measurement values (temperature, humidity, DC1, DC2 power) and status of parameters (red corresponds to problem and green corresponds to no problem).

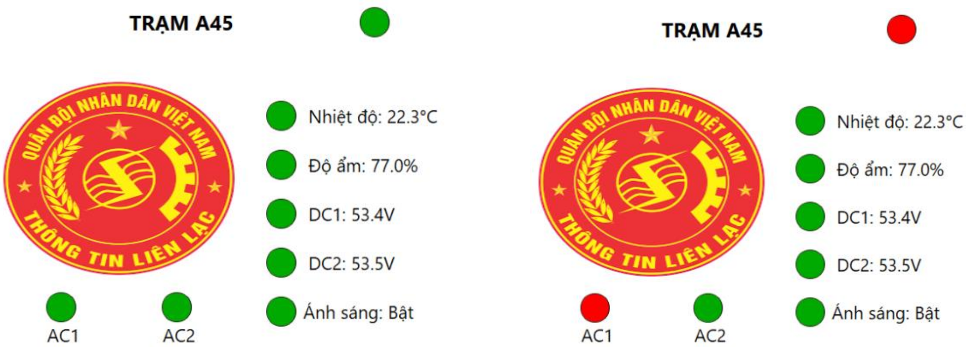

Figure 16. *Display interface of a station on software*

The statistical chart of temperature over time of station A45 is shown in Figure 17. The chart illustrates the good operating temperature threshold (20-25^0C), displaying the measured value in blue (every 5 minutes) when the temperature is within the threshold and red when the temperature is outside the threshold (problem), the time of the problem beginning and ending are displayed immediately on the software for the supervisor to promptly handle.

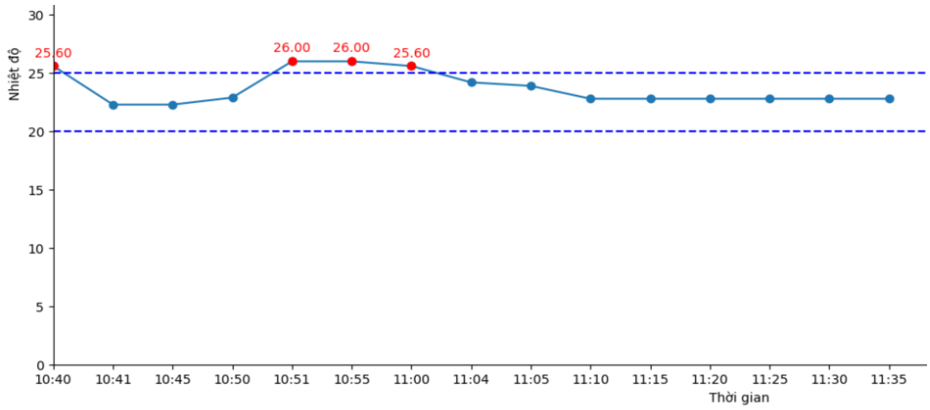

Figure 17. *Statistical chart over time of temperature*

Besides the function of displaying the value and status of measured parameters, the software also has the function of statistics problems in table over time. The table contains information on the start and end time of the problem and can extracts data into Excel file for storage and reporting purposes (Figure 18).

Sự cố về điện áp AC1

Tên sự cố	Thời gian bắt đầu	Thời gian kết thúc
Sự cố AC1 mất	2024-04-07 10:47:57	2024-04-07 10:48:53
Sự cố AC1 mất	2024-04-07 11:06:23	2024-04-07 11:07:49

A	B	C
Tên Sự Cố	**Thời Gian Bắt Đầu**	**Thời Gian Kết thúc**
Sự cố AC1 mất	2024-04-07 10:47:57	2024-04-07 10:48:53
Sự cố AC1 mất	2024-04-07 11:06:23	2024-04-07 11:07:49

Figure 18. *Statistics of problem in table and extract to Excel file*

4. Conclusion

The centralized monitoring and management system of communication stations is designed, manufactured and tested to operate stably, continuously monitoring power parameters and working environment conditions, promptly providing warnings on-site, via mobile networks and on software. The system allows many units to simultaneously monitor and manage communication stations. The device has a compact size, low maintain and operating costs, and can be easily installed at communication stations. When the system is put into operation, it will enhance the efficiency of technical assurance for communication units, especially for unmanned communication stations. Monitoring and data storage software can be installed on any computer connected to the military data transmission network. Therefore, the centralized monitoring and management system for communication stations can be widely applied in communication units. In addition, data transmission via military LAN will ensure the security of transmitted data. The system can be improved to apply to monitoring and managing communication warehouses and military warehouses.

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