

## Distributed Control System in Electrical Heaters of the Public Buildings

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### Abstract

Being with many advantages such as environmental protection, controllable, facilitate measurement etc, electric heating has been promoted actively in some places. For public buildings with huge energy consumption, electric heating intelligent controlling may be the key to achieve energy conservation. In this paper, visual distributed control system (DCS) was presented in electric heating of the public buildings. In this control system, a PC was used as the host, and RS232/485 interface converter was used as serial interface of mutual conversion. Through industrial standard RS485 bus with high reliability and low cost which was the link between the host and many sets of thermostat, a one-to-many communication network was formed. The MCU of the thermostats was ATmega8 microcontroller. Meanwhile, DS18B20 integrated temperature probe was used in temperature sensor. Through the DCS test online, it met the need of each individual heating unit. Therefore, unnecessary heat waste was reduced, heating costs were saved.

**Keywords:** public building, electrical heaters, distributed control system

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### 1. Introduction

Heating in winter in the north of China has an important influence on the people's lives and work. Most traditional central heating such as water heating means induce such a waste of resources and environmental pollution. Some relevant provinces have begun to actively promote clean electrical heating means to replace traditional heating methods. Now many heating methods are applied, but electric heating will be the future trend of heating in the energy saving, environmental protection, perspective [1, 2].

Heating on demand is the development direction of the winter heating. Electric heating has many advantages that other heating methods do not have, such as easy to measure and control. In the public buildings, the energy consumption is extremely huge, thus using electric heating would be of great significance in promoting energy conservation and environmental protection. Electric heating is controllable and facilitate in measurement. So in public buildings, electric heating and intelligent control are the key to achieve intelligent energy-saving. Intelligent control of heating will be the direction of development in the future.

### 2. DCS Distributed Control System

DCS is the abbreviation of the Distributed Control System. It is a multilevel computer system including control level and process monitoring levels by communication network. DCS is synthesized by Computer, Communication, CRT and Control. The basic ideas of the 4C technology are decentralized control, centralized operation, classification management and flexible configuration, easy configuration [3]. DCS control system is widely used in the production factories and production lines, the control effect is significant. In public buildings, though some intelligent controls are used in heating system, most controlling systems are established in the one-chip computer, PLC control to realize the part of centralized control function, and hard to achieve the ideal control targets.

### 3. Electric Heating Distribution Control in Public Buildings

#### 3.1. Control Objectives

DCS can be used in electric heating controlling system in public buildings such as schools, hospitals, hotels and so on, due to the large number of heating units, with different heating time and different heating temperature. According to the special circumstances, the way of distributed control system includes chronological preset control requirements (as for school) and temporary control requirements (such as hospitals, hotels) to adjust control parameters. The goal is to realize maximum heating energy-saving by careful centralized control and individual heating demand through the DCS. Control objectives are as following [4].

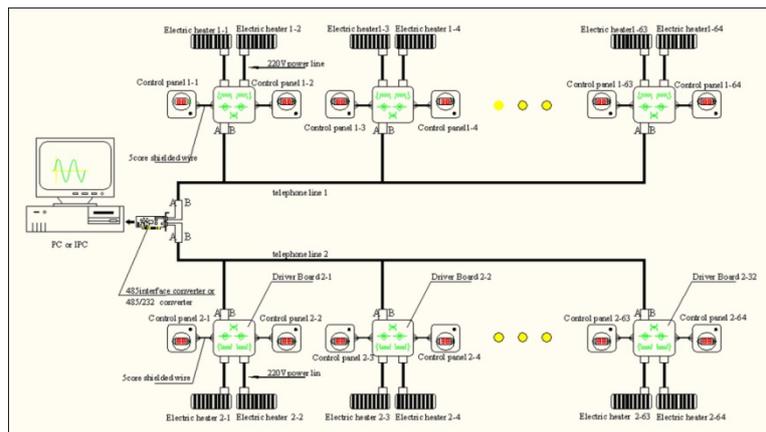


Figure 1. Diagram of Control System

Realizing central control in multiple rooms; realizing microcomputer programming control, according to the requirements of different periods and different rooms respectively; setting a variety of programs; installing double displays including central control room and independent room; setting and recording stored history, inquiry, statistics; networking can be inquired at any time, setting procedure by manager; realizing real-time temperature data acquisition and processing, real-time temperature data of visual display; temperature off-gauge alarm; temperature data of records, including alarm data and historical data; temperature measurement parameter setting, including temperature measuring point parameters, communication and parameters of the temperature statements parameters; temperature data report management.

Centralized control: centralized control of manager, installation debugging (single phase online testing function), monitoring the room temperature, the temperature parameters and the working condition. Decentralized control: temperature display, work instructions, temperature regulating in temperature controller.

#### 3.2. Control System Structure

The public building heating DCS system is composed of a host (PC or industrial PC) as the core and multiple controllers by network [5]. High-performance single chip microcomputer and integrated sensor are composed of high performance and high precision terminals-thermostats. Each controller is in charge of the each electric heater according to instructions of the host. RS485 BUS is used to compose one-to-many communication network [6]. The controlling principle chart is as Figure 1.

To realize the following main modules by VB:

(1) DCS Main modules can realize the DCS in various lists to realize remote polling and give-out order in accordance with the procedures in storage temperature directives to each remote thermostat.

(2) Service module: operation records and control permissions management, inspecting whether the data backup is normal or not, single terminal normal debug, and power-off saving.

(3) ActivX module, it is responsible for the use with the thermostat through a serial of communication of the PC to exchange data. The exchange data interface is put on display or processing.

The communication between PC software and thermostat is realized by standard ActiveX control, which is a standard middleware to realize the underlying communication drive, equivalent to the thermostat drive function by standard ModbusRTU communication protocols. This ActiveX control can be used for other development environments (just as VC, Delphi, etc.) for secondary development by programmers [7].

### 3.3. The Main Functions of the Control Process

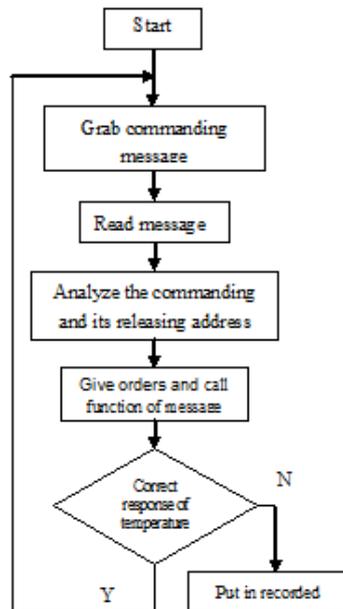


Figure 2. Flow Chart of Host Sending Instructions to Lower Computers

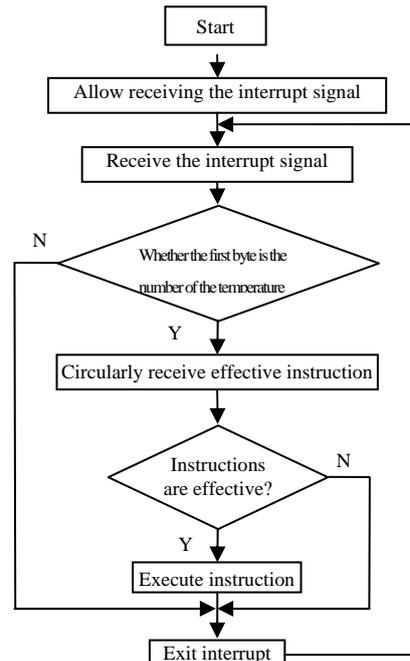


Figure 3. Flow Chart of Temperature Controller Receiving Interrupts Instruction

In DCS temperature control system, the lower computers control temperature of heaters, and receive instructions from the host using interrupt command has shown in Figure 3.

### 3.4. Communication Protocol

Regulation of communication protocol is as follows: a communication baud rate of 9600bps, 4MHz crystal oscillator [8].

The communication protocol of temperature controller is ModbusRTU agreement by the standard, in which includes four instructions: 0x01 (read internal digital and maintain coil state), 0x03 (read internal analog and maintain memory contents), 0x05 (set internal single digital and maintain coil state), 0x06 (set a single analog inside and maintain memory contents)

## 4. Hardware Environment

DCS control system is adopted in public building heating control system to realize the operation control of the visualization. Electric heating distributed control system consists of a PC as host connecting with many temperature controllers by RS232/485 interface converters and industrial standard RS485 bus, to compose the one –to–many communication network structure and to realize communication and data processing. By Basic6.0 ActiveX control and application of Visual Basic6.0 technology, the effective communication distance can reach 1200m under



**5.1. Access Permission**

In this System, three users are set to operation as Figure 7. Only correct user name and passwod are allowed to access premission of all command and control the whole system .

At the same time, the control permissions and fault alarm window, operation records data backup and many other functions are also designed to ensure the system working safety and efficiency just as Figure 8.

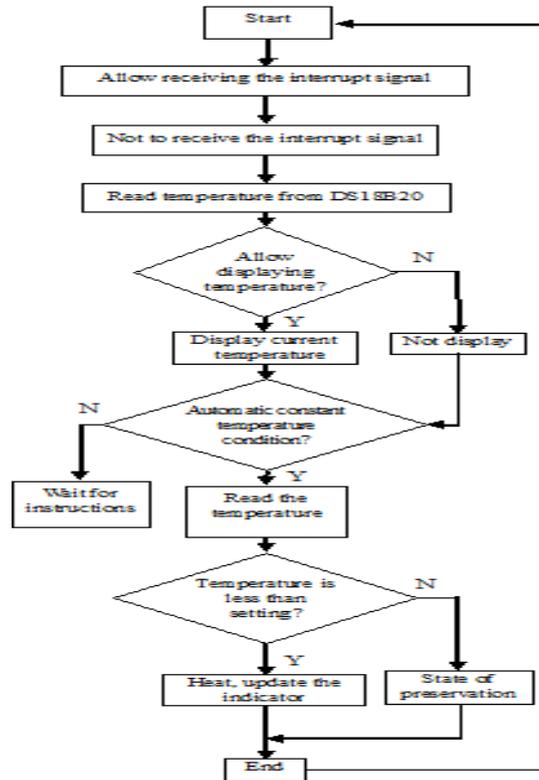


Figure 6. Flow Chart of Temperature Controller Working

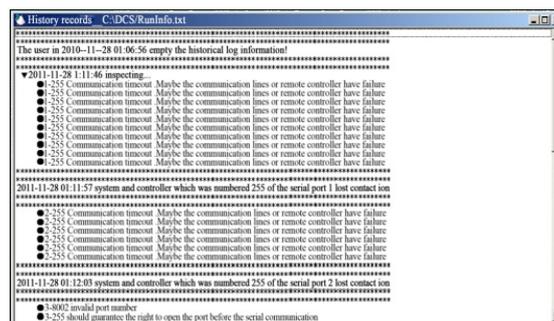


Figure 8. Operation Records

DCS system is a network distributed control system, and is composed of multiple points (thermostat). So we need to set each control point of information. In this system, relevant content can be edited and deleted.

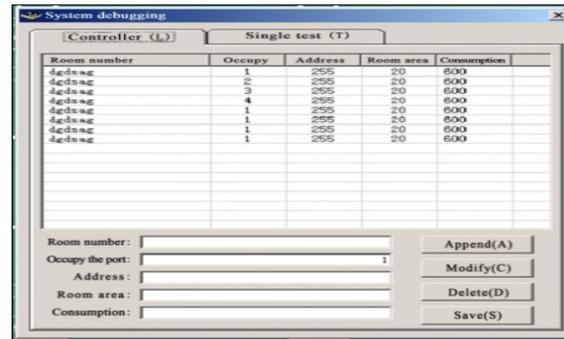


Figure 9. Setting the Control Points

## 5.2. System Debugging

Being numbered in advance, every room has corresponding temperature controller. When we set the system, controller can be selected according to the list. Meanwhile, a specific controller can be debugged and set address. These are showed in Figure 9 and Figure 10.



Figure 10. System Debugging

## 5.3. Other Function

When the system is detected and a controller loses touch, the system will timely report to the user. Then fault alarm window will be showed, and this window will keep flashing to draw attention to the operator.

When the DCS system interface opens, system inspection begins immediately, then communicates and sends control commands to thermostat of each room in proper order.

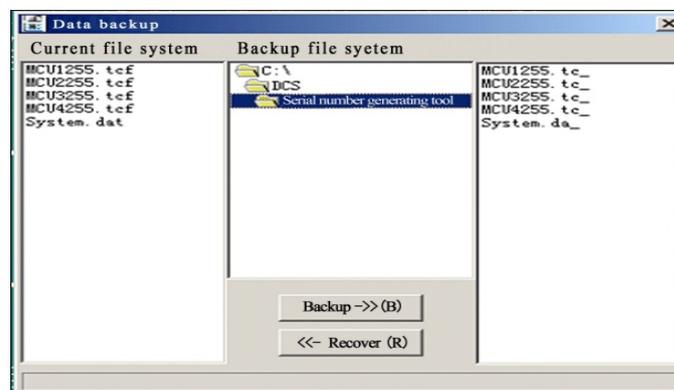


Figure 11. Data Backup

This control system has the function of data backup. If the hardware failure of the user computer causes the DCS system stop running which is not be repaired in a short time, through replacing a computer and installing this software, the data will be recovered to make the DCS system perform command as normal.

## 6. Conclusion

Through this control system, the functions are realized as following:

The simple, reasonable and convenient distributed control system with good performance hardware and simple software with expansibility can satisfy all sorts of control requirements to realize safety control of electric heating system in public buildings and improve its reliability and flexibility and to realize the dynamic management of each control unit, centralized control and supervision. Through the scientific control, the system guarantees warming comfortably and energy saving.

Electric heating distributed control system adopts advanced system design method, is based on ActiveX controls, can realize data transmission and communication, also can be applied to drives in other different development environments. By the controls, users not only can establish control system quickly, but also expand use scope and function according to the need.

The system is adopted in three public buildings in 2009, 2010 and 2011 winter. By comparison the electric heating using DCS control and traditional water heating, the initial investment and operation cost reduces about RMB 300 millions yuan. More important points are reducing pollution and saving energy significantly.

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