I.J. Wireless and Microwave Technologies, 2012, 3, 9-15
Published Online June 2012 in MECS (http://www.mecs-press.net)
DOI: 10.5815//ijwmt.2012.03.02

Available online at http://www.mecs-press.net/ijwmt

The Research of On-line Monitoring System of Power Cable Joint Temperature

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Abstract

Power cable joint is the weak link of power system's safe operation, it is important significance to real-time master the operating temperature of power cable joint for the safety of the power system. This paper adopts wireless technology to design the temperature monitoring system of power cable joint. Monitoring terminal collection temperature data located in each power cable joint collects the measured data in the cable branch box through the near distance micro-consumption electronic wireless technology to data concentrators located at the bottom of the cable branch box, then transmits to the monitoring center through CAN bus network. The system realizes the low cost and on-line reliable monitoring of power cable point temperature of the urban cable branch box.

Index Terms: Power cable joint, temperature monitoring, wireless technology

1. Introduction

Power cable joint temperature monitoring in the cable branch box of urban power has the important practical significance for improving the safety and reliability of urban power cable operation. The current temperature monitoring device that can used in the cable branch box of urban power has the faults of the inconvenience of installation and maintenance and the high cost of application, and so on, which restricts its application and dissemination. According to the practical needs of power supply enterprise, after investigation, analysis and study, the Strategy uses wireless technology to design a set of new power cable joint temperature monitoring system. Monitoring terminal collection temperature data located in each power cable joint collects the measured data in the cable branch box through the near distance micro-consumption electronic wireless technology to data concentrators located at the bottom of the cable branch box, then transmits to the monitoring center through CAN bus network. The system realizes the low cost and on-line reliable monitoring of power cable point temperature of the urban cable branch box.

2. The Overall Structure of Power Cable Joint Temperature Monitoring System

According to the analysis, the whole monitoring system can be divided into three layers: control layer, communication layer and equipment layer. The monitoring center located in power supply company send control command to the field device through CAN network, the field device receives commands and executes the corresponding operation according to the command, then transmit the implement result to the monitoring center through CAN network. According to the specific equipment, it can also be divided into monitoring terminal, data concentrators and the monitoring center server. The structure figure of the system is shown as figure 1.

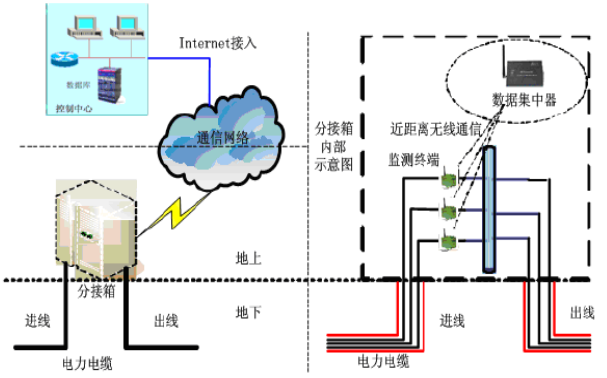

Fig 1. The structure figure of the system

2.1. The Hardware Design of Monitoring Terminal

The circuit design of monitoring terminal uses modular structure. According to the front of the scheme and the principle of low power consumption, small volume, Stability and reliability, the function of monitoring terminal completes temperature data collected, communicates with data concentrators and completes data exchange. The structure chart of monitoring terminal is shown as figure 2.

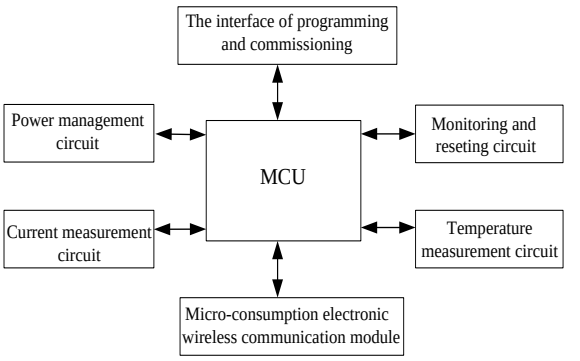

Fig 2. The structure chart of monitoring terminal

1) Low power consumption micro-controller

The low power consumption and mixed signal controller of MSP430 which has superior performance and rich peripherals can be basically satisfied with needs of terminal battery low power. According to hardware needs, MSP430F1222 is chosen for terminal controller. When the voltage is 1.2V and clock frequency is 1MHZ, the working current of MSP430F1222 is only 220uA, the dormancy current in LPM3 mode is 2.5 uA, the ADC of 10bit 200kb/s is embedded in internal, which has the 16 bits of three capture/comparative registers and watchdog timers and provides program the code protection of safe fuse. The FLASH code storage space of 4KB and 256B RAM can meet the requirement of system design.

2) The close wireless communication circuit

The nRF2401A launched by Nordic company in Norway is the 2.4 GHz of single chip wireless transceiver chip, which has the advantages of a receiving high sensitivity, a less peripheral circuit, a lower transmission power, a higher transmission rate and low power consumption. nRF2401A is the same as Bluetooth which work in the free frequency of 2.4GHz and are unimpeded in the global wireless market. nRF2401A supports multi-point communications and a higher transmission speed compared with Bluetooth, and the maximum transmission rate can reache1Mb/s. It is designed by the SOC method and can compose RF transceiver circuit used less peripheral components. nRF2401A is different with Bluetooth, which does not have the complicated communication protocol and is completely transparent to users. It can freely communicate between same products. It is important that nRF2401 is a cheaper than Bluetooth products. So nRF2401A is a Low cost RF transceiver of small volume, low power consumption and a less peripheral component.

3) The temperature data acquisition circuit

Because there is the powerful electromagnetic interference around high voltage power cable joint and should ensure the precision and stability of measurement and consider all aspects of a high temperature resistant, waterproof, volume and convenient installationThe scheme chooses single bus of digital temperature sensor DS18B20 launched by the DALLAS semiconductor company in America. DS18B20 which has the advantages of small volume and strong anti-interference ability is a digital temperature sensor and can adapt the bad environment of the power cable joint of the cable branch box.

2.2. The Hardware Design of Data Concentrator

Data concentrator connects the monitoring center through CAN bus and uses wireless communication with monitoring terminal. Its working reliability and stability relates directly to the whole system operation, which is the key of the system communication layer. According to the function orientation of the data concentrator, the modular structure design thinking is used in the system. The structural design of the data concentrator is shown as figure 3.

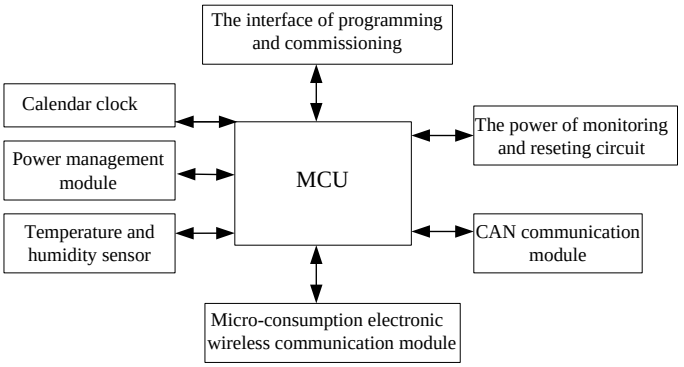

Fig 3. The structural design of the data concentrator

1) The choice of Micro-controller

Data concentrator also chooses MSP430 MCU, it is different with terminal that GPRS communication relates to the application of CAN bus agreement and reduces the difficulty of the program design. Because the embedded operating system is used in the system, it needs the more program storage space and data storage space compared with MSP430F1222. The MSP430F149 which has a more function and a richer resource in MSP430 is chosen to improve the stability of the system and reduce the difficulty of design.

2) CAN communication circuit

CAN bus communication circuit consists of three components: the main controller, CAN controller and CAN transceiver. The main controller is MSP430F149, CAN controller MCP2510 provides control and management ability of CAN bus, CAN transceiver provides the driver ability of CAN bus.

3) Real-time calendar clock circuit

In order to simplify the terminal design and reduce the volume of the terminal, calendar clock function is realized by data concentrator. The low-power real-time clock chip DS1302 which is launched by DALLAS in America is chose in the system. The real-time clock chip DS1302 can count to second, minute, hour, day, mouth, week, month and the year which takes a leap year compensation and has 31 * 8RAM to save useful data. Read and write used for clock or RAM data has the data transfer mode of single byte or more bytes. The interface circuit of DS1302 is shown as in figure 4

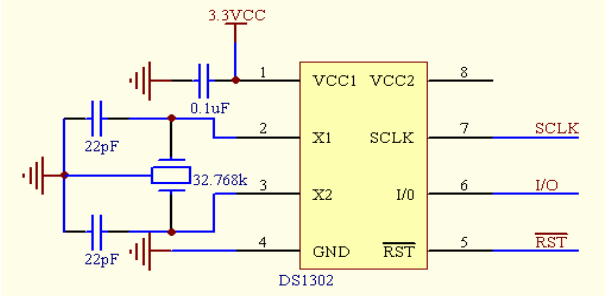

Fig 4. The interface circuit of DS1302

3. Monitoring Center

Data concentrator connects the monitoring center through CAN bus and uses wireless communication with monitoring terminal. Its working reliability and stability relates directly to the whole system operation, which is the key of the system communication layer. According to the function orientation of the data concentrator, the modular structure design thinking is used in the system, which consists of microprocessor unit, short-range wireless communications unit, power management unit, CAN bus communications unit and so on. The short-range wireless communications unit uses nRF2401A, and power solution uses the multiple CT of maglev inductive power in power cable terminal, the response electricity is charged to battery, then battery will be supply electricity to data concentrator.

Monitoring terminal is in sleeping mode and accesses to active state every time to detect the air signal. If the sensei signal is detected, monitoring terminal will retreat to sleeping mode to collect data, then return to the data concentrator and transfer to the concentrator, which realizes the low power consumption of monitoring terminal and provides the precision of temperature measurement and the service life of monitoring terminal.

3.1. The Software of Monitoring Center Server

The monitoring center is composed by the master server and database server. The main server installs the processing software of real-time monitoring and data analysis, database server stores the history monitoring data. The monitoring center server software is the key of the whole monitoring system, which intensively manage and command the operation of the whole monitoring system, mainly includes the content of the following aspects:

1) The receiving communication

Communication function refers to communicate with data concentrator in the cable branch box and receives the collected data from data concentrator to store in the backend database through the corresponding analysis and processing, such as temperature, current and environment temperature. Meanwhile, the control command is sent to the data concentrator in the cable branch box to realize timing acquisition and data transmission.

2) Monitoring management and quality evaluation

Monitoring management and quality evaluation is the concentrated and finally reflection of the whole monitoring system function, and the purpose is that the temperature data of power cable joint is real-time monitored in the cable branch box and analyses and processes data combined with other reference data(current, environmental temperature), which can accurately masters the operation state of the power cable joint to realize the real-time monitoring and warning of the cable joint temperature and is relatively effective quality assessment.

3.2. The Composition of Software Structure and Function

In the monitoring system, the server software needs to prevent harmonic and complete the data communication of data concentrator in the cable branch box and calculates and analyses all kinds of data collected in the site to deposit in database to display for the reference of operational personnel and accept to operated by operational personnel. Server software structure is shown in figure 5.

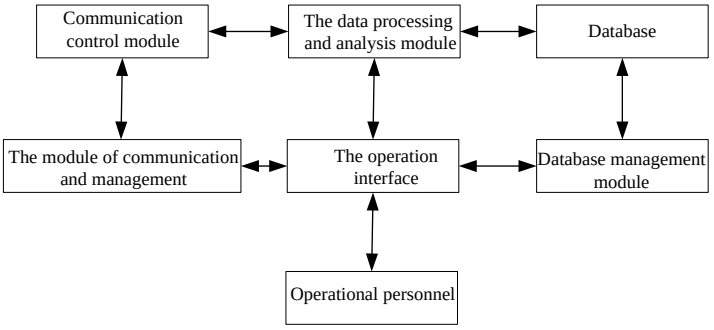

Fig 5. Server software structure

The user interface system graphically displays the information of the data and state from the site equipment, which is the interface of operating personnel and the cable joint temperature monitoring system. On one hand, the data processing and analysis system converts on-site control command from graphical interface to the corresponding content of communication protocol to send communication control system. On the other hand, it interprets, processes and analyses the receiving data of communication control system to transferred to the database program or interpret the identifiable information to display for user through the user interface system. Correspondence control system is responsible for receiving data and handle user control command and system command, which works with data processing and analysis system and user interface system to realize the function of the master server software. The main functions provided by server software for user is shown in figure 6.

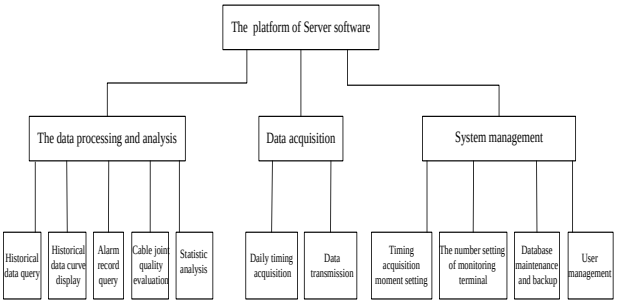

Fig 6. The main functions provided by server software

3.3. The Design of the Main Program

The main function of the main program initializes the micro-processor and the periphery connection device and controls the program flow. Time dealing subroutine updates and reads the time value for terminal device. Temperature gathering subroutine collects the various power cable joint temperature and judges whether the temperature is more than the permissible value. Display subroutine circularly displays the temperature of various power cable joint to observe in the field. Communication receiving subroutine receives all sorts of command sent by PC. Communication sending subroutine sends warning signal or sends the corresponding data from the command of PC to the PC. The main program flow chart is shown as figure 7.

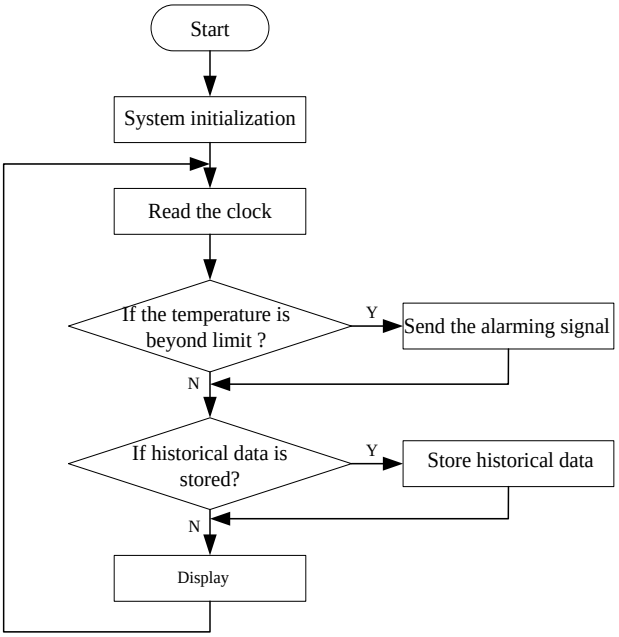

Fig 7. The main program flow chart

4. Conclusion

The temperature monitoring of power cable joint is the necessary link of the safe and reliable operation of the power system. The low power consumption and the induction power is used in the system. Micro-consumption electronic wireless communication is used in monitoring terminal and data concentrator to realize the effective data transmission and the high voltage isolation, and data concentrator connects control center through CAN bus network to achieve the low cost remote on-line monitoring, which effectively solves the problems of urban power cable joint temperature on-line monitoring to realize the on-line monitoring of urban power cable joint temperature on-line monitoring.

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