The Design of Intelligent Low Voltage Circuit Breaker Remote Data Monitoring System

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Abstract—This paper designs a remote data monitoring system for intelligent low voltage circuit breaker. Data collector collects various state parameters such as current, voltage and opening or closing state of each phase from intelligent low voltage circuit breaker by RS485 bus and uploads to master station by GSM/GPRS mobile network. The main station processes the data transmitted from the lower layer and displays various parameters and states in real time. At the same time, it sends commands to the intelligent low-voltage circuit breaker to make corresponding actions. This realizes remote monitoring and protection of various parameters and operating conditions of low voltage electrical appliances effectively.

Keywrod—intelligent low voltage circuit breaker; remote data monitoring system; data collector monitoring software

I.   INTRODUCTION

As one of the important electrical components in the distribution system, the circuit breaker undertakes the connection and disconnection of the circuit; and it can reliably and rapidly cut off the circuit in the event of overload, short circuit and ground faults for protecting the electrical distribution network and industrial equipment from damage. Because many distribution intelligent circuit breakers are far away, distributed, large and complex in geographical environment, it is very important to realize remote data collecting and monitoring, and meet the requirements of real-time and reliability. [1]Therefore, designing a intelligent low-voltage circuit breaker system based on networked remote control, which can conveniently monitor and manage all kinds of monitoring information, operation information, on-line operation parameters and control network working parameters, etc., anytime, anywhere, or even in the moving. [2]Effectively realize the remote monitoring and protection of the operating status of various parameters of low voltage electrical appliances.

II.   DESIGN OF OVERALL SYSTEM

Structure of intelligent low voltage circuit breaker remote data monitoring system is shown in Figure 1.

The system includes three parts: an intelligent low-voltage circuit breaker, a data collector, and a host station PC.[3] The intelligent low voltage circuit breaker includes signal conditioning circuits, data collection and processing units, RS485 communication units, extended memory units, and power supply modules. The data collector includes four parts: data receiving and processing unit, RS485 communication unit,

GSM/GPRS signal processing communication unit, and power supply.

The data receiving and processing unit of the data collector collects the data and state parameters of the intelligent low voltage circuit breakers through the RS485 communication unit, and reports the information to the main station layer by the GSM/GPRS communication unit. And it receives instructions from the main station and sends it to the on- site intelligent circuit breaker. The main station periodically collects data from the GSM/GPRS communication unit, and has the functions of storing historical data, monitoring and fault warning, and sending control commands to the on-site intelligent circuit breaker.[4]
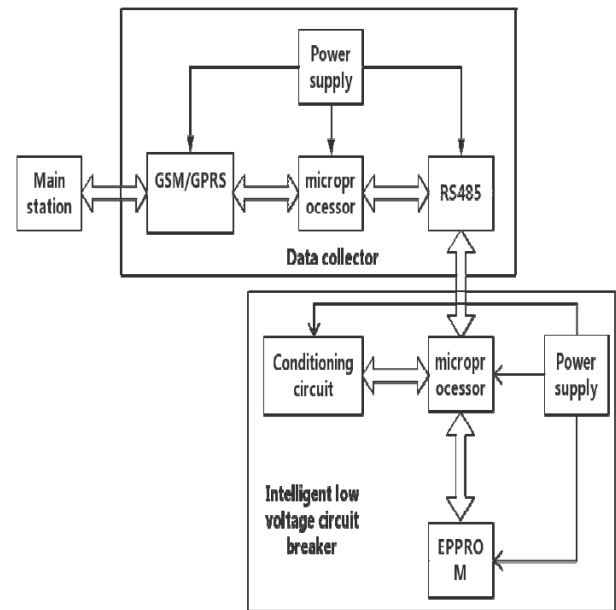

FIGURE I. INTELLIGENT LOW-VOLTAGE CIRCUIT BREAKER DATA REMOTE MONITORING SYSTEM STRUCTURE DIAGRAM.

III.   DETAILED DESIGN OF THE SYSTEM

A.   Design of Intelligent Low Voltage Circuit Breaker Data Collection and Processing Unit

The 16-bit PIC24FJ128GA306 RISC microcontroller module is used in data collecting and processing unit. This module not only has the advantages of ultra-low power

consumption, small size and low cost, but also has a rich set of peripheral functions and enhanced computing performance. The 16 channel 10 bit ADC is integrated into the chip, allowing the channel to be selected and immediately converted without waiting for the end of the sampling period. The chip also contains a series of serial communications peripherals that can be used to implement export communications through an external RS232/485 converter. Circuit diagram of intelligent low voltage circuit breaker data collection and processing unit is shown in Figure 2.
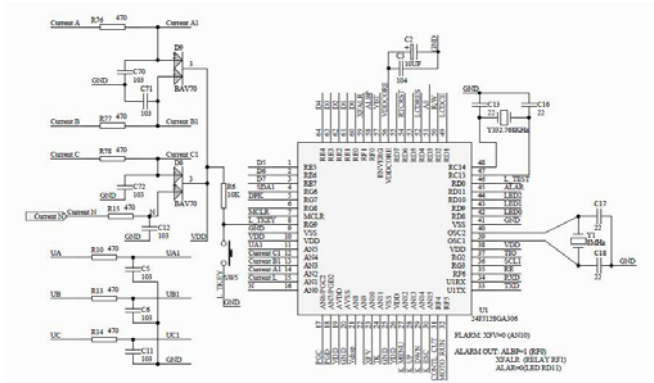

FIGURE II. CIRCUIT DIAGRAM OF DATA COLLECTION AND PROCESSING UNIT OF INTELLIGENT LOW VOLTAGE CIRCUIT BREAKER.

B. Signal Conditioning Circuit

After A, B, C phase current and N phase current are rectified by LB2S, the current of A, B and C is amplified by operational amplifier respectively, and then sent to the data collecting terminal of single chip microcomputer. Signal conditioning circuit is shown in Figure 3.
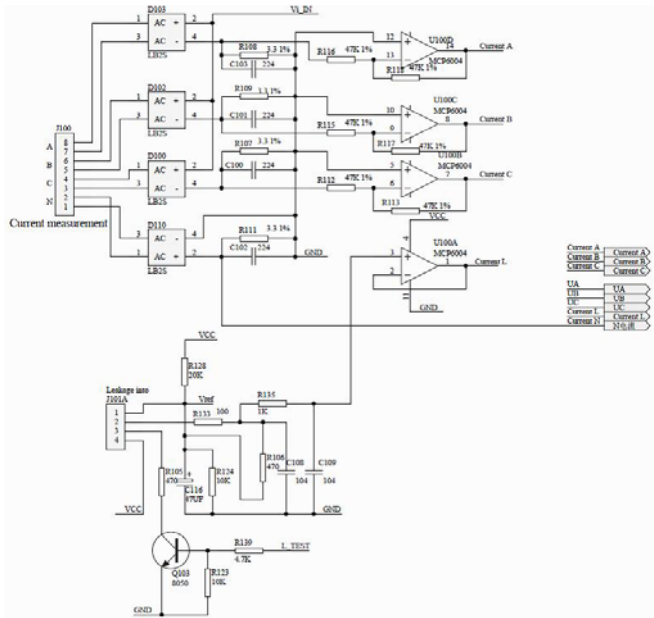

FIGURE III. SIGNAL CONDITIONING CIRCUIT.

C. Design of Data Collector Circuit

The circuit wiring diagram of the data collector is shown in Figure 4. PIC24FJ64GA006 was selected as its CPU.RS485 communication adopts SN75176 differential bus transceiver, wireless communication adopts GSM/GPRS module, it supports maximum 42.8Kbps/85.6Kbps uplink and downlink data transmission rate.
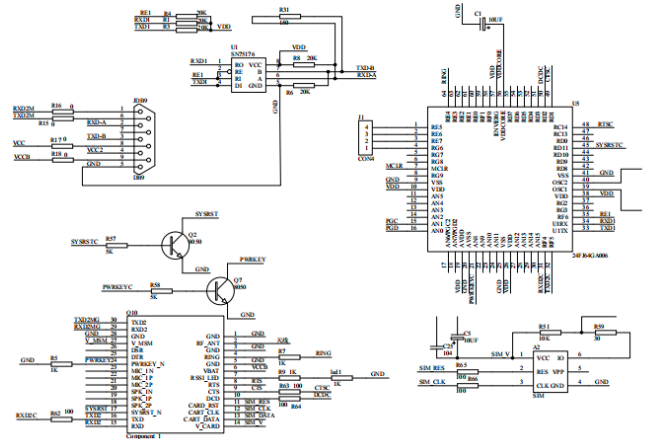

FIGURE IV. DESIGN OF DATA COLLECTOR CIRCUIT.

IV. DESIGN OF SOFTWARE SYSTEM

The design of software system is divided into two parts, the upper computer management software and the data receiving and processing software according to the hardware circuit and the application range. The data receiving and processing software is divided into three parts: data collecting module, RS485 data transmission module, and GSM/GPRS data transmission module.

A. Software Management of Upper Computer

Block diagram of upper computer management software shown in Figure 5.
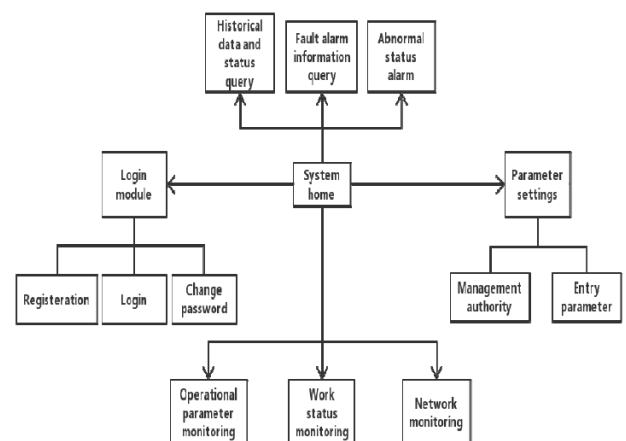

FIGURE V. BLOCK DIAGRAM OF UPPER COMPUTER MANAGEMENT SOFTWARE.

As the upper computer of the intelligent low voltage data collecting system, the main functions of the host computer include real-time monitoring functions, query functions, setting functions, and fault alarm functions. The inquiry function mainly includes inquiring the current and historical data of A, B, C phase voltage and A, B, C phase current and leakage current, the current and historical state of the intelligent low voltage circuit breaker, etc.; The setting function mainly includes the current time setting, the setting of the three-phase current and the three-phase voltage rating of the intelligent circuit breaker, and the setting of the leakage current; The fault alarm function includes the opening and closing commands of the intelligent low voltage circuit breaker and the fault diagnosis and fault alarm of the communication.

The upper computer software is written by C# of the Visual Studio platform. After the data collector connects to the server through TCP/IP, the upper computer software sends a scan command to obtain the IP address and physical address of the data collector. At the same time, the type and quantity of low-voltage circuit breakers collected by the data collector are stored in the database to facilitate administrators' query and control. The database management platform adopts Microsoft SQL Server. The query data interface and the real-time measurement data interface are shown in Figure 6 (a) and (b).

(a) Query data interface

(b) Real-time measurement data interface

FIGURE VI. DATA MONITORING INTERFACE.

B. Design of Data Collector Software

The design of data collector software mainly includes two parts from the function: First, the data collector receives the three-phase voltage, three-phase current, and leakage current data and switch status of each intelligent low voltage circuit breaker and then uploads it to the master station. Second, the data collector receives the command issued by the master station and transmits it to the intelligent low voltage circuit breaker at the site.[5] The flow chart of Data collector software is shown in Figure 7.
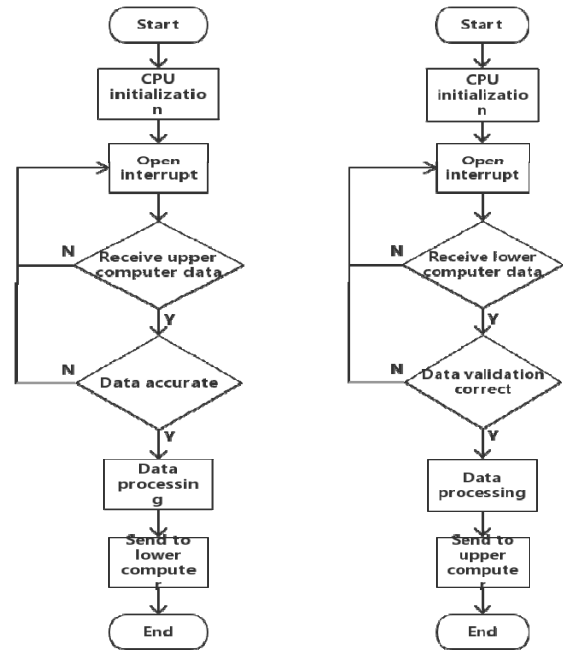

FIGURE VII. THE FLOW CHART OF DATA COLLECTOR SOFTWARE.

C. Design of Communication Protocol

1) The communication of monitoring terminal to data collector

The TCP-IP protocol is used between the monitoring terminal and the data collector on the GSM/GPRS wireless network platform.[6] In order to ensure the reliability of data, we use a way to answer questions. The protocol includes the following sections:

a) General format: it is used for monitoring terminal control the median computer to query and set the lower computer parameters;

b) Heartbeat: It is used to maintain the communication between the middle computer and the upper computer. If the upper computer does not access the registered middle machine within 30 seconds, the middle computer actively sends a heartbeat packet to indicate its existence;

c) Login packet: it is used for the middle computer to report its GSM/GPRS module address to the upper computer to establish the basic contact;

d) Setting range of median computer collection address: the upper computer sets the type and address of lower computer to be collected by the middle computer;

e) Fault fast report: The median computer scans the lower computer. If a fault report is found, it is quickly reported to the upper computer to handle the fault.

2) The communication protocol of data collector to intelligent Low voltage circuit breaker

Because the installation of the intelligent low voltage circuit breaker scattered, requiring a long transmission distance, a large amount of data and poor communication environment, we use RS485 master-slave communication. It is requiring the use of grounded shielded twisted pair, communication speed 9600B / S, 8-bit data bits and no parity. The maximum number of access terminals is not more than 64.[7]

The communication between the data collector and the intelligent low voltage circuit breaker uses Modbus protocol, RTU mode. The message sending should start at least 3.5 characters' pause interval. The entire message frame must be transmitted as a continuous stream. If there is a pause of more than 1.5 characters before the frame is complete, the receiving device refreshes the incomplete message and assumes that the next byte is the address field of a new message. If a new message in less than 3.5 characters of time and then began a message before, receiving equipment will think it is a continuation of the previous message, which will result in an error, because in the last check domain value can't be right.[8] The protocol is as follows:

a) The query function

i. Query the circuit breaker status: when the data collector sends a command of query the slave status to the intelligent low voltage circuit breaker, it collects the status of the circuit breaker and transmits it back to the data collector. The status of the circuit breaker includes the following: trip alarm status, transient Trip, phase loss, zero-break, phase A overcurrent, phase B overcurrent, phase C overcurrent, remote trip, leakage fault, phase A overvoltage, phase A undervoltage, phase B overvoltage, phase B undervoltage C phase overvoltage, C phase undervoltage and open state;

ii. Query the circuit breaker measurement data: When the data collector sends the query circuit breaker measurement data command to the intelligent low voltage circuit breaker, the data collector collects various current and voltage data of the circuit breaker and returns to data collector.

iii. In addition, there are query alarm history data and query circuit breaker setting parameters.

b) The setting control functions

i. Setting the current time: when the intelligent low voltage circuit breaker time is inconsistent with the system running time, it can be corrected by setting the current time command;

ii. The parameter setting of the intelligent low voltage circuit breaker: the data collector can set various operating parameters of the lower computer;

iii. Opening and closing: The data collector controls the opening and closing of the intelligent low voltage circuit breaker by sending commands.

Because the setting control function is related to the normal operation of the intelligent low voltage circuit breaker, it needs to be authenticated by the authority when modifying.

c) Check the response command

Each command above must be verified before it can be processed; otherwise an error message will be returned.

V. CONCLUSION

This paper designed a remote monitoring system of intelligent low voltage circuit breakers based on PIC24FJ series microcontroller. It achieved distributed, long-distance transmission and large data low voltage data collection and monitoring combined with RS485. It was implemented on GSM/GPRS module based on TCP/IP. The wireless long-distance communication adopts the one-to-one communication method to ensure the reliable transmission of information and uses a flexible and diverse modular program design to meet the user-defined function requirements.

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