Design of Interface Software for a Distributed System With Mixed Varied Intelligent Meters*

Zheng Zhenyao, Dong Jiyang and Chen Zhong**
Department of Physics
Xiamen University
Xiamen, Fujian, China 361005
zzy129960@126.com

Cao Zhikai and Jiang Qingyin
Department of Chemical Engineering
Xiamen University
Xiamen, Fujian, China 361005
xdceds@xmu.edu.cn

Abstract—Main problems of the common Communication Interface Software (CIS) for an industry-control network based on RS485 bus are poor openness, flexibility and stability, so some functions of intelligent meters are limited. A new CIS was designed by the following ways: the RS485 serial communication process was composed of physical and application layers; the interface initializing process related to communication at physical layer was described by normalized communication module; the common parts of order message creation and responsive message transmission were described by a data structure and the special parts of them were described by text files respectively; configuration software was used to interpret these descriptions. The software has characteristics of broad generalization and operational facilitation, and can run on Windows completely. The results in application cases show that the software is effective and feasible.

Keywords—communication software, serial communication, industrial control, intelligent meter

I. INTRODUCTION

Since the RS485 bus has advantages of high reliability, strong anti-jamming, simple structure, convenient maintenance, and long transmission distance, it has been widely applied. Belonging to the physical layer of 7-layer open system interconnect reference model (OSI), the RS485 is only normalized in electrical characteristics of the receiver and the transmitter, and its communication protocols is still vacant. So far most communication interface software is designed into modular structure, namely, the interface software for an intelligent meter is designed to be an independent module. Different protocols are normalized by different manufacturers, resulting in varied communication interface modules.

In practical industrial applications, there are varied objects and tasks, so varied intelligent meters coming from different manufacturers are adopted in order to satisfy the needs. When control objects and tasks change, it requires reconstructing and extending the control system, as causes the following progrenent problems. (1) Process control system is poor openness. When the control system increases and replaces intelligent meters from different manufacturers, special interface software modules for the new intelligent meters must be redesigned, with excessive workload of programming and debugging, and a long cycle. (2) The communication between controller and intelligent meters is not agile and stable. (3) The different control objects and tasks have a variety of control parameters, the numbers of which are from several to over one hundred. Due to disadvantages of communication software, some functions are limited. These factors baffle to some extent the further applications and developments of the network control system based on RS485 bus.

This paper analyzed the communication process in distributed industrial control network with mixed varied intelligent meters. Based on RS485 bus, an interface software with broad generalization was developed to make communication between controller and intelligent meters agile and stable. It also improved the openness and expansibility of process control system. The interface software enables simultaneous communication with intelligent meters from different factories, and runs on Windows completely.

II. ANALYSIS OF COMMUNICATION PROCESS AND DESIGN OF INTERFACE SOFTWARE

Network of industry control adopts the structure of principal and subordinate, namely, the industry controller (principal) sends orders and data to (or read data from) intelligent meters, which send data to the principal according to its orders or requirements. One RS485 interface can link with 32 intelligent meters in the same time and identify the meters by the unique address code. Since the controller, as the principal, has only RS232 interface, a transforming module RS485/RS232 with photoelectric isolation is needed.

RS485 serial communication process is composed of physical and application layers. At physical layer, the principal and subordinate use identical communicating rate and data format, which is divided into data bit, stop bit, and parity bit. The data bit can be address. At application layer, order/answer mode is adopted. The principal sends order message, and the subordinate corresponds to what it receives. Each kind of answer message corresponds to one kind of order message, respectively. Generally, the complete message format is given by:

Start segment + Address code + Function code + Data segment + Check code + End segment.

* This work is partially supported by Economic & Trade Commission of Fujian Province.
** Corresponding author.
The meanings of these fields are as follows:

**Start segment:** Starting code of communication or period without signal input.

**Address code:** Subordinate address assigned to receive messages from the principal.

**Function code:** Functions that should be completed by the assigned subordinate.

**Data segment:** Decided by function code, it contains needed information that helps to complete specific functions.

**Check code:** Code acquired by processing data above in some way.

**End segment:** Ending code of communication or period without signal input.

The intelligent meters made by different manufacturers are normalized in communication mode at physical layer. Their communication rates support the baud rate usually used. However, the specification of data format is not normalized. The digit number of data bits is 5, 6, 7, or 8; that of stop bits is 1, 1.5, or 2; besides there are 5 different check modes, namely NONE, ODD, EVEN, MARK, and SPACE. There are a variety of protocols for application layer. Intelligent meters made by different manufacturers have different address code, data segment code, way of making check code, and interval of correct response.

If the general module structure is adopted, it is required to program for messages of each product respectively, resulting in heavy workload and poor generalization.

We adopt another scheme. By analyzing message communication process at application layer, it can be divided into 5 steps, including creation of order message, initialization of communication port, transmission of data, reception of data, and transformation of responsive message. Among these steps, initialization of communication port, transmission of data, and reception of data are related to communication at physical layer, so normalized communication mode can be used to describe them and general programs can be compiled. The program way to actualize the creation of order message and transformation of responsive message is to decompose the whole communication process into two parts: common part and special part. Uniform data structure is used to describe them. The common part is described by fixed program, while the special part is transmitted to the software system by configuration file and message form file. After interpreted by interpretation programs, the special part is executed by the corresponding communication program. A simple message form file of an intelligent meter is described in normalized mode. The communication can be completed in this way as long as a simple message form file combining with the configuration software of control system is loaded.

1) **Common part:** Varied intelligent meters have slight difference in initialization of communication port, transmission and reception of data in communication process, so general modules can be adopted. For example, the port initialization program is:

```c
int InitCom (int port, int baud rate, int mode);
parameters: port (communication port);
 baud rate;
```

2) **Special part:** The special parts of intelligent meters from different manufacturers are mainly on the design schemes of function code and data segment. These parts can be simply described with text file in the identical mode. The contents include function codes, data length, data type, and radix point. With these descriptions, order messages can be created and responsive messages can be transformed precisely in communication.

3) **Configuration:** Descriptions for communication protocols of varied intelligent meter are achieved with configuration software, which includes communication port, baud rate, communication mode at physical layer, function code of signals, and communication interval, etc.

The interpretive programs for writing and reading are as follows:

```c
int write_value(unsigned char addr, float *pv,
                float *oldpv, unsigned char readnum, int len=1) {  
  int id,i,ik=0;
  char ch1,ch2;
  float a1,b1;
  for(i=0;i<len;i++) {
    ch1=YGmode[readnum][1];
    ch2=YGmode[readnum][2];
    df.d=0;
    a1=*pv;
    switch(ch1) {
      case 1:    a1*=10;  break;
      case 2:   a1*=100;  break;
    }  
    if(ch2=='P'||ch2=='b') df.d=int((int *)pv);
    else df.d=int(a1);
    id=Data_Io(addr+1,readnum,Write);
    if(!id)  ik++;    
    pv++;  oldpv++;  readnum++;
  }
  return ik;
}
```

```c
int read_value(unsigned char addr, float *pv,
                unsigned char readnum, int len=1) {  
  int id,i,ik=0;
  char ch1,ch2;
  for(i=0;i<len;i++) {
    if(ch2=='P'|ch2=='b') df.d=*int pv;  
    else df.d=int(df.d);
    id=Data_Io(addr+1,readnum,Read);
    if(id)  ik++;
    pv++;  oldpv++;  readnum++;
  }
  return ik;
}
```
```c
ch1=YGmode[readnum][1];
ch2=YGmode[readnum][2];
*pv=0;
id=Data_Io(addr+1,readnum,Read);
if(!id) {
    ik++;
    if(ch2=='f'&&ch2=='F')
        *pv=float(readdata[3])*fpoint[ch1];
    else  *(int *)pv=readdata[3];
}
pv++;
readnum++;
}
return ik;
}
```

The programs designed by this way have characteristics of small codes and broad generalization, especially fitting intelligent meters complying with protocols of the Modbus. When the control system adds or replaces a different intelligent meter, it is not necessary to design new special software module. It is only required to compile the special part with text file, as makes the system open and mutually operational. The principal can not only read the output data from intelligent meters, but also set all parameters of the meters. The programs designed facilitate system maintenance.

### III. DESIGN OF THE COMMUNICATION PROGRAM

Communications between the principal and subordinate ask different normalizations and managements for different characteristics of parameters, order, and data. It is not easy to realize communications by general programmed algorithm.

We make use of functions of Windows to achieve the communication easily. The communication flow chart is shown in Fig.1. Key techniques based on Windows are adopted in software design, such as:

#### A. Event Driven Communication Queue

A single-way RS485 network can be linked with as many as 32 intelligent meters while communication rate between the principal and subordinate is not high, and there is much communication waiting time because the principal communicates with multiple intelligent meters via only single communication port by the polling way. So it is necessary to set up a communication queue for every intelligent meter. The communication queue communicates with the intelligent meters according to the communication priority, which can be fractionized based on the type of communication.

#### B. Combination of Timing with Real-time Communication

Communications between the principal and the subordinate can be divided into 4 types: read-write communication of configuration parameters of the subordinate, control orders sent by the principal, transmission of data of the subordinate running status under the principal supervision, and transmission of sampling data from subordinates. The first and second type of correspondences require real-time process; while the third and last type of them require timing process, where the communication intervals are different according to the level of importance of transmission data, maybe as short as some seconds or as long as some tens of minutes. To solve problems of timing correspondence, all tasks of correspondence are defined as signals, and communication modules communicate with these signals by the polling way.

#### C. Fault Diagnosing and Sufferance-fault Techniques in Communication

If the principal sends a message to a subordinate, but the principal fails to receive completely the responsive signals from the subordinate within setting time, this subordinate is set to be in communication fault. Thus, the communication ends and the next task of communication continues. So communication modules of the principal will not be hanged up due to communication interruptions of some subordinate. After abnormal correspondences have happened continually for 3 times, the system is identified to be in fault and switched to exception handles. Considering that there may be wrong codes resulted from factual disturbance during the communication process, data are sampled only once and then the resulting value is compared with that acquired in the last time. If the difference between them oversteps the setting threshold value, the value got this time will be taken for a result of disturbance and rereading is needed. Otherwise, this value is processed as factual one and a signal of communication fault is presented.

![Fig. 1 Communication Program Flow Chart](image-url)
IV. AN APPLICATION CASE

An industrial computer control system discussed above has been employed to control tea-baking process at Anxi Tea factory in Fujian province. 4 vector frequency converters (VFC) regulate the stepless speed of the electro-motors in the tea-baking box to control the baking time. 15 temperature measurement meters were employed to detect 3 tea-baking boxes and 1 tea-cooling box. 3 electromotor valves were used to control the baking temperature by adjusting the cold air flow. 3 temperature controllers were used to control above 3 electromotor valves. And 1 hygrometry meter was used to measure the environment humidity. The control system has two levels of supervision schemes, with industry computer as its principal and intelligent control meters as its subordinates. The principal has only RS232 interface, so a transforming module RS232/RS485 with photo electricity segregation is needed. This module transforms data mutually between RS485 and RS232. So far a RS485 industrial control communication network was upbuilt between industrial computer and intelligent meters, and the network is shown in Fig. 2.

Other parameters and orders, such as turn-on and turn-off, were set to be real-time communication signals. In the distributed industry-control network with varied intelligent meters based on RS485 bus, spot temperature, humidity, valve level, control signals were all prescribed as timing signals, and more than 30 groups of data were gathered and saved by timing regularly in the principal; set parameters in varied meters and PID parameters in the controller were set as real-time signals, and can be updated at any moment.

Although varied intelligent meters made by different manufacturers were used in a control network at the same time, the communication work became easy when we used the interface software and configuration software proposed by this paper. Unified transferring and controlling by unified control interface were achieved at the principal, and same complicated works of setting parameters concerning keys on VFCs and meters panel were avoided. All parameters can be saved in the principal, optimized parameters can be transferred back directly after an intelligent meter is replaced, and the maintenance has become an easy job. Now this system is running in the industrial spot, with steady communication and effective controlling, and the quality of baking tea is greatly improved.

V. CONCLUSION

For distributed industry-control network with varied intelligent meters based on RS485 bus, the software of communications interface improved the openness of process control system, having characteristics of broad generalization and operational facilitation, making the communications between controller and intelligent meters agile and stable, running on Windows completely. The application case in the industry spot has testified the feasibility of this communication software. Which is expected to facilitate the use of the similar control system.

REFERENCES