IOP Conf. Series: Materials Science and Engineering **322** (2018) 072033 doi:10.1088/1757-899X/322/7/072033

Realization of PLC to the Variable Frequency Speed Regulation System of Mine Local Ventilator based on RS-485 Communication

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Abstract: The article first introduces the merits of serial communication in the PLC to the variable frequency speed regulation system of mine local ventilator, and then sets up a hardware application development platform of PLC and inverter based on RS-485 communication technology, next presents communication initialization of the PLC and Inverter. Finally according to the control requirements, PLC send run operation & monitoring instruction to Inverter, realizes the serial communication control between the PLC and Inverter.

1. Introduction

In the coal industry, the PLC is widely used to control the inverter to drive the mine local ventilator and real-time adjust the air flow according to the change of the pipe resistance and gas concentration since it can reduce the ventilator and electric energy consumption. The outputs of the PLC drive the relay to control the running states of the inverter including start, stop, forward and reverse, and the frequency of the inverter is set up by the outputs of D/A module of the PLC or external knob.

The defects of this control system are the large number of electrical components, complex connection, and high maintenance workload. Meanwhile, it will cause the loss of precision, control distance limitation and poor anti-interference ability when using analog quantity (0-5V, 4-20mA) to control the setting signal of inverter frequency. Thus, the control method of RS-485 communication could be an effective solution. Through one RS485 communication cable, the operations of start-stop to PLC and inverter and frequency setting can not only be realized, also it is able to monitor the operating frequency, current and voltage of inverter. Besides, this control method has the advantages of simple wire connection, far transmission distance, omission of the D/A module of PLC, and high precision and stability of the setting speed.

Taking controlling the operations of mine local ventilator as an example, this article will give a solution to how to achieve the communication between MITSUBISHI FX2N PLC and MITSUBISHI FR-E500 inverter. MITSUBISHI GOT100 touch screen is applied for monitoring the operation control and statues of the ventilator.

2. System Composition and Connection

The whole system is showing as Figure 1. It is composed of computer, touch screen, the PLC, inverter and a small power ventilator. In the computer, for PLC programming, GX-developer is used and GT-Signer2 is the design software for touch screen. Next, the USB interface and “penetration

functions" will write the program and screens into PLC and touch screen for debugging. The model of USB communication cable is GT09-C30USB-5P. The interface for touch screen and PLC is RS-422 (model: GT01-C30R4-8P), the port connected with touch screen uses DB9 connector，and the other connector for PLC is 8-DIN-connector.

For the realization of serial communication between PLC and inverter, a FX2N-485BD communication board needs to embed in the PLC and connect with the interface of the inverter with a self-made cable. The detail connection between the board and RJ45 interface for RS-485 communication of inverter is showing as Figure 2. The outputs (U, V, W) of the main circuit of inverter are respectively connected to the three-phase terminal of local ventilator.

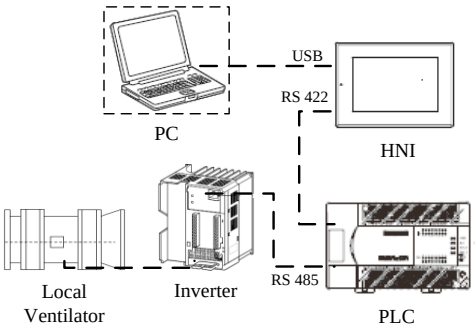

Figure 1. The control system

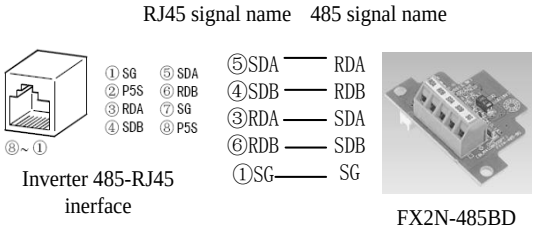

Figure 2. Inverter RJ45 interface for RS-485

3. Communication Initialization and Control Procedures

3.1. Parameter Initialization Of Inverter

In order to achieve the RS-485 communication between PLC and inverter, it is necessary to initial relevant parameters of the inverter, such as the number of the station, the communication rate, the stop bit, parity, the times of communication attempts and so on. Without initialization or error settings, the data wouldn't be transmitted. On the other hand, the inverter has to be reset after every initialization, otherwise, the communication parameters will not be updated and communication will failed. Main parameters of the inverter are shown in Table 1.

Table 1. Parameter Initialization Of FRE540

Pr.	Name	Set Value	Description	Example Value
117	Station No.	0-31	communication No.	2
118	Communication rate	48/96/192	4800 /9600 /19200 b/s	96
119	Length Byte/Stop Bit	0 //1	8 bit/1 bit // 8 bit/2 bit	
		10 //11	7 bit/1 bit // 7 bit/2 bit	10
120	Parity	0/1/2	None/Odd/Even	2

Table 2. The format of D8120

Bit No.	Name	Description
b0	Data length	0 (bit=OFF) 1 (bit=ON)
		7 bit 8 bit
b1/ b2	Parity	(b2,b1) 0,0:None ; 0,1:Odd ; 1,1:Even
b3	Stop bit	1 bit 2 bit
b4/b5/b6/b7	Baud rate(b/s)	(b7,b6,b5,b4) (0,0,1,1):300 ; (0,1,0,0):600 ; (0,1,0,1):1200; (b7,b6,b5,b4) (0,1,1,0):2400 ;(0,1,1,1):4800 ; (b7,b6,b5,b4) (1,0,0,0):9600 ;(1,0,0,1):19200 ;
b8~b15		0000 0000

3.2. PLC Communication Initialization

In addition to the inverter parameters, PLC also need to initial related settings and have to keep the same format with the inverter. The communication initialization of the PLC is determined by D8120, a dedicated data register. The format of D8120 as shown in Table 2, in this case, the length of data is 7 bits; stop takes 1 bit; parity check take 2 bits; baud rate choose 9600. Use MOV command can write H86 into D8120.

In addition, initial setting also has to be done to RS instructions (Send and Receive data, no protocol communication between the PLC and external devices), data transmission flag (M8122), finished receiving flag (M8123) and 8 bits/16 bits changeover flag (M8161)

Figure 3. PLC Communication Initialization

Detail initial setting shows as Figure 3, firstly, write the communication format into D8120, next specify the head addresses of send and receive data in D20 and D40 separately in RS instruction, then set M8161 to ON as communication data of inverter is 8-bits while the OFF of M8161 is 16-bits. A pulse instruction X001 sets M8122 in the waiting to send state, and M8122 will automatically reset when finish sending. In comparison, the flag M8123 will be turned on automatically for receive completion, but it should be reset by "RST" instruction.

3.3. Communication Protocol and Formats

The sequence chart of RS-485 communication between the PLC and inverter is showing as Figure 4:

① The PLC transmits data to inverter**;**

② Data processing time of inverter;
③ Data return to PLC;
④ PLC delay time;
⑤ Response to return data.

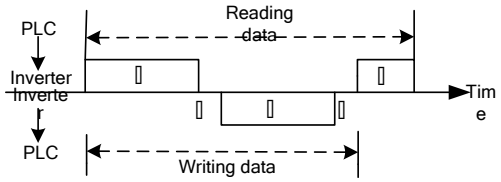

Figure 4 . The sequence chart of communication between the PLC and inverter

Confirming communication protocol & formats according to transmission data type - writing or reading is the first step for programming. Then convert the data into ASCII code and send to relative registers. ASCII code is the only format that the inverter can recognize.

Communication Formats may include three categories according to serial communication sequence between the PLC and inverter:

① Based on the communication requests from the PLC to inverter, there are A, A', A" and B four formats according to data length and different demands of reading or writing;
② Based on the response data from inverter to the PLC, format C and D according to error data or not;
③ Based on the reading data from inverter, the PLC receives numerical value from the inverter; such as operating current, voltage and frequency; defines E, E' and E" formats according to data length,

And in which, the communication requests, data transmit start, data transit end and no error data found are denoted by control code “ENQ, STX, ETX, ACK” respectively, and they have relative ASCII code.

4. Realization of Communication Control

4.1. Operation Control of Ventilator

The PLC sends operation instructions to inverter, the format is A’, in this case, the station number of inverter is 2, operation instruction code is FA, forward is H02, reverse is H04, stop is H00. The data sent by the PLC needs to convert to ASCII code since the inverter can only recognize ASCII code. The forward instruction format and ASCII code as shown in Figure 5.

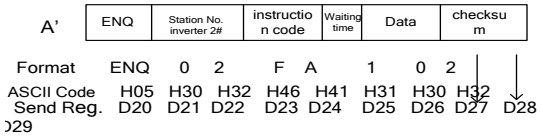

Figure 5 . The forward instruction format and ASCII code

Valid data is written into ten registers from D20, the data in D26 and D27 make the decision to forward, reverse or stop for the inverter, valid data for summation check are stored in registers D21 to D27, the final hexadecimal checksum (using instruction “*CCD*”) is in D38&D39 register and its ASCII code is stored in D28 and D29, setting M8122 will send the data to inverter. Using control instruction X0 as forward, X1 as reverse and X2 as stop to control the inverter. Parts of the program and explanation are in Figure 6.

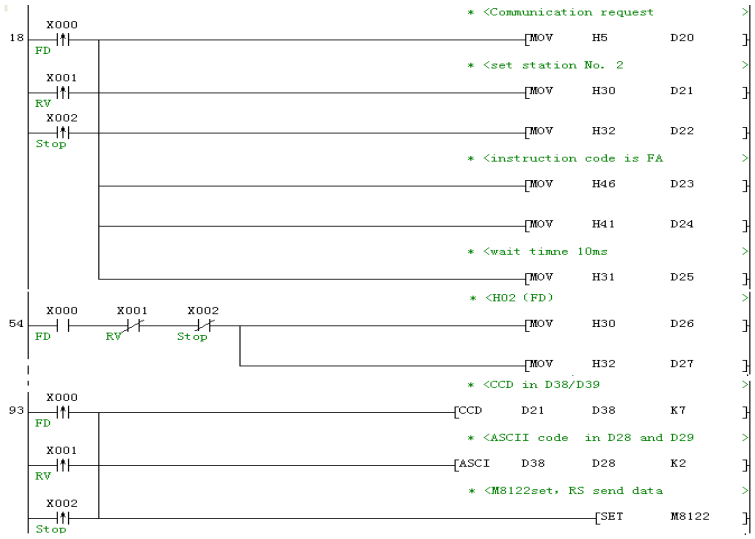

Figure 6 . Parts of the program of operation control

4.2. Running State Monitoring

Displaying the operation frequency, current and voltage of inverter on the touch screen requires the data from the PLC and inverter communication.

The Program is designed into two parts:

(1). The PLC sends reading requests to inverter, using format B. The station number of inverter is No.2; according to the inverter manual, request codes for frequency, current and voltage are H6F, H70 and H71. The PLC has to convert data into ASCII code since it is the only format that the inverter can recognize.

Figure 7(a) provides the format of frequency request and its ASCII code. Valid data stored in eight registers from D20 to D27, and the instruction codes in D23 and D24 will decide content of this request, i.e. frequency, current or voltage of the inverter. Data for summation check is in D21-D25, final checksum code in D26 and D27 is hexadecimal and has to convert into ASCII code. Sending data for both monitoring and inverter operation control uses the same registers, so these two processes are fully interlocked.

(2). The PLC receives response from the inverter. The lengths of the data for frequency, current and voltage are all 4 bits, so the format should use format E. Format and ASCII code for received data show in Figure 7(b).

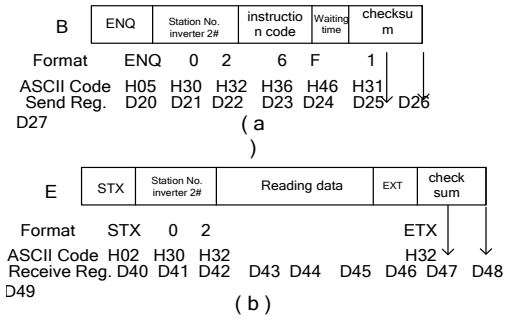

Figure 7 Format and ASCII code

Received data is in ten registers from D40 to D49. The reading data from inverter is separately in D43 to D46 and they are all ASCII code, so "HEX" instruction is needed in program to convert ASCII code from inverter into hexadecimal number. Main program for this part and explanation shows in Figure 8. M0, M1, M2 are monitoring requests for reading frequency, current and voltage.

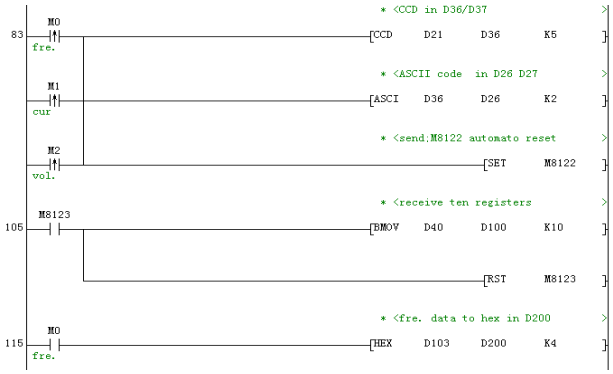

Figure 8 Parts of the program of State Monitoring

"SFTLP" instruction is used to realize the alternated turn-on for M0, M1 and M2 due to the PLC reads only one of the three parameters (i.e. frequency, current and voltage) at some moment and thus, the three parameters are able to have the continuous display on touch screen. Program is in Figure 9.

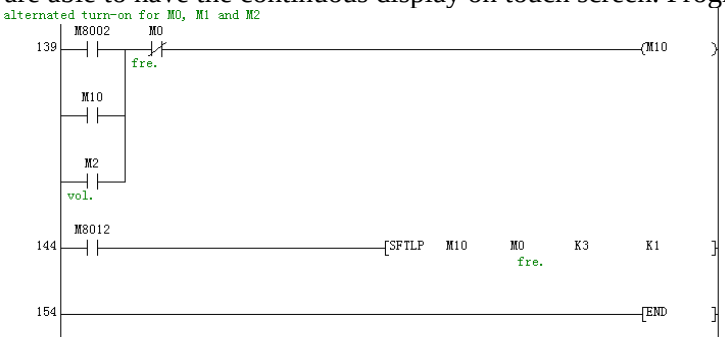

Figure 9 Three parameters continuous display

5. Conclusion

This article implements the operation control and state monitoring based on the hardware installation, communication initialization, PLC programming and system commissioning. The actual operation of this system shows the good communication and reliability of devices. This system deserves promotion and widely application for its low cost, high energy efficiency, stable operation and it tremendous enhances the safety of colliery automatic production.

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