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A technique to expand the I/O of the PLC Using remote I/O module

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Abstract

In this paper, a technique to expand the Input and Output (I/O) of the programmable logic controller (PLC) using remote I/O module is presented. The controller and the remote I/O module should have the same protocol and are interfaced through RS 485. Each remote I/O module consists of 16 digital input and 16 digital output, and the maximum of 32 remote I/O module can be linked to one controller. The remote I/O is programmed for interrupt request to controller independently. Therefore, there is no affect to the scan time of the controller. Using this technique, the PLC can be efficiently applied to the several hundred meters different control points such as the ON-OFF control for the agriculture farm, the building automation system, a multi group of machine control.

1. Introduction

A programmable logic controller (PLC) is widely used in the industrial control system. The developments of PLC are to expand the control points, to develop the instruction programming to be easily used, mora applications and more intelligence, to develop the interfacing with the other system and to develop the controlling with long distance. This paper presents a technique to expand the Input/Output (I/O) of the PLC using the remote I/O module. Typically, there are many methods to expand the control points such as the parallel bus connection with I/O expansion module, additional of the controller numbers. But there is limitation in distance in the control task and difficult to centralize control in both methods. Generally, the communication between the controller and the remote I/O module is the polling method. The controller has to polled data with every module.

This paper presents a technique to expand the I/O of the PLC using some concept of fieldbus technique. The remote I/O module which is connected to the PLC by the serial communication of the IEC fieldbus RS485 standard [1]. The communication media is the twisted pair with the several hundred meters for each remote I/O module. Each remote I/O module consists of 16-bit digital input and 16-bit digital output, and the maximum of 32 remote I/O modules can be linked to one controller. This means that the maximum control points 512 points are arranged. Furthermore, this technique has the interrupt instruction in the PLC. Each remote I/O module is programmed for interrupt by this instruction. Therefore, the scan-time of the controller is not effected.

2. FieldBus Concept

The automatic control system in industries have many kinds of field device (e.g. sensor, actuators), and many kinds of process control. The fieldbus concept needed to combine the signals from many kinds of the process control equipment to be the same signal by digital communication [1], [2], [3].

The traditional communication standard known as 4-20mAdc [2] (e.g. transmitter, I/P transmitter). This standard provides for point-to-point connection which consists of all information exchanged between field and control devices in both directions. The great number of field devices being used require a lot of cables. This is the problem in installation and maintenance and the documentation work as well.

The fieldbus concept is basically a digital communication, which is capable of interconnecting field devices with control system in any process control environment. The fieldbus communication architecture in the term of node will be used to refer to a field device. The fieldbus devices have wide varieties of field devices. There are simple devices such as the limit switches, relays, single-contact device and dumb actuators; the simple intelligent devices such as the transmitters, the receivers; the intelligent actuators; smart sensors; the complex devices such as the programmable controllers, PID and other loop controllers, etc. The fieldbus supervisor is the central controller that takes the total responsibility for initializing the bus, establishing what devices are attached to it and monitoring its activities. the fieldbus device topology is shown in Fig. 1. The fieldbus system are currently available in the market several venders. But none of them used an international standard, and only the IEC/ISA fieldbus communication system that is in the final stage of standardization [2].

3. System Configurations

The system consists of the PLC to be used as the fieldbus supervisor and the remote I/O module as the fieldbus device. The fieldbus device and fieldbus supervisor are connected through the twisted pair in form of the bus topology. Each remote I/O module has the unit number in order to identify the fieldbus device. Fig. 2 shows the connecting between the PLC and the

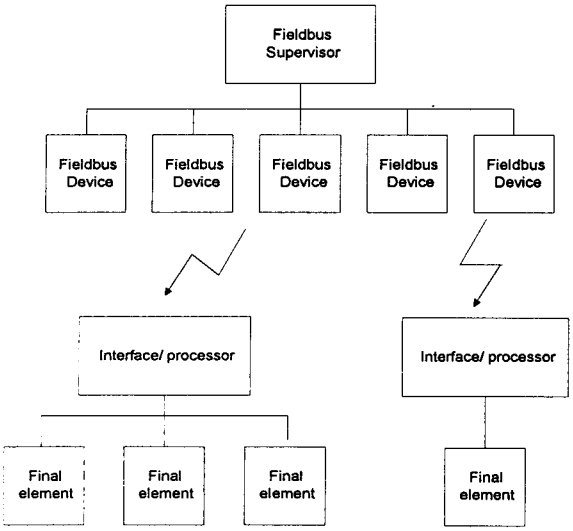

Fig. 1. The fieldbus device topology.

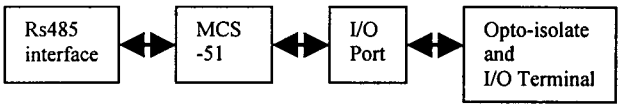

Fig. 2. The block diagram of remote I/O.

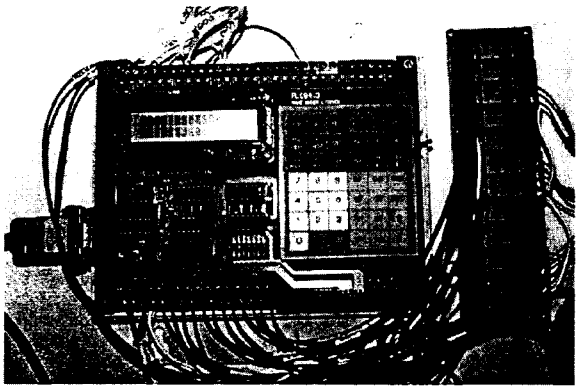

Fig. 3. The programmable logic controller (PLC).

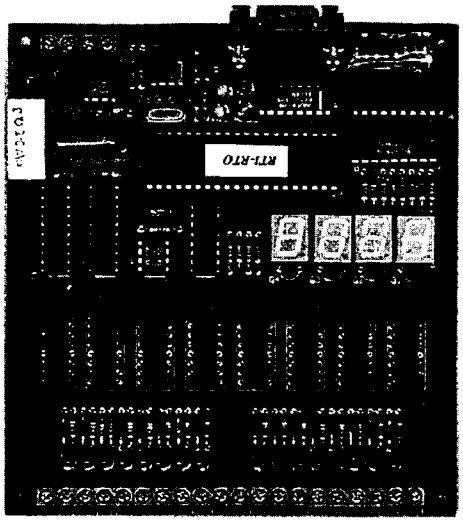

Fig. 4. The remote I/O module.

remote I/O module. The unit number can be set from the dip switch which run from the unit 00 to unit 31. The unit number must have the different number. Fig. 3 shows the PLC that used microprocessor No. Z84c11 [4] as the Central Processing Unit (CPU). The PLC consists of opto-isolated 24 inputs and 12 outputs .The sequential operation control program and the special function, such as shift register, can be written down to PLC through build in keyboard. The PLC has the build-in serial port RS485 to expand the control points by remote I/O module. The programming language being used is the Ladder Diagram instruction. The monitoring function which used to observe the status of the PLC operation is also included. Fig. 4 shows the remote I/O module that used the microcontroller MCS-51 as the CPU for manages the digital communication, such as the protocol and the interfacing with I/O port. The input output port is protected from the outside electrical signal by the opto–isolator. Fig.5 shows the connection between the PLC and the remote I/O modules.

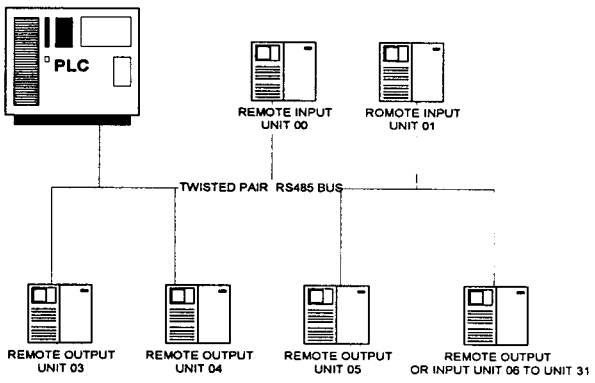

Fig. 5. The connecting between the PLC and the remote I/O modules.

5. The protocol design

The controller and the remote I/O module use the same protocol. When the controller is programmed to request the data from the remote I/O module, the controller has to send the command block through all of the fieldbus devices. Then the remote I/O module which be requested will send back the response block immediately. Fig. 6 shows the block format.

@	Unit Number	Header	Data	*	FCS	[CR]

Fig. 6. The block formats.

The meaning of each section in the block format is explained in the Table 1 and Table 2, respectively.

@	Start block character
Unit Number	Node number refer to field devices (00 - 31)
Header	Command code (ASCII Code 2 characters) **RD** : Read data from input module **WR** : Write data to output module **MD** : Module Description to check modules which are connected. (The type of modules)
Data	Information message (ASCII Code 2 - 4 character) **RD** : None information. **WR** : The hexadecimal code data instead of the binary 16 bits **MD** : None information.
*	Close block character.
FCS	Frame Check Sequence to recheck data by XOR each of character and compared the result of XOR calculated between source and destination. The result has to match.
[CR]	Carriage Return code

Table 1. Command block.

@	Start block character
Unit Number	Node number refer to field devices (00 - 31)
Header	Response code (ASCII Code 2 characters) **RD** : Return Data from Input module to the PLC. **MD** : Module Description is the type of module.
Data	Information massage (ASCII Code 2 - 4 character) **RD** : The hex code data instead the binary 16 bits. **MD** : 00 : Output module. 01: Input module. **ER** : 00: Over range character. 01: Format error 02: Unknown command. 04: Execute error.
*	Close block character.
FCS	Frame Check Sequence to recheck data by XOR each of character and compared the result of XOR calculated between source and destination. The result has to match.
[CR]	Carriage Return code

Table 2. Response block.

5. Operation of the Instructions

The instruction used the ladder diagram programming in order to send or receive the information with the remote I/O module. The ladder diagram programming is named as RDI is the instruction to read data from remote I/O and WRO is the instruction to write data to remote I/O. This ladder instruction is controlled by the interrupt request control relay. If the condition of the interrupt request control relay is logical "1" then the controller will create and send block command to read or write data depend on the program requested. Therefore the controller not necessary to communicate with the unconcerned remote I/O module. In this case, the scan time of the controller is not effected. Moreover, adding or removing of the remote I/O module can be done independently. The flowchart of the WRO and RDI instruction is shown in Fig. 7.

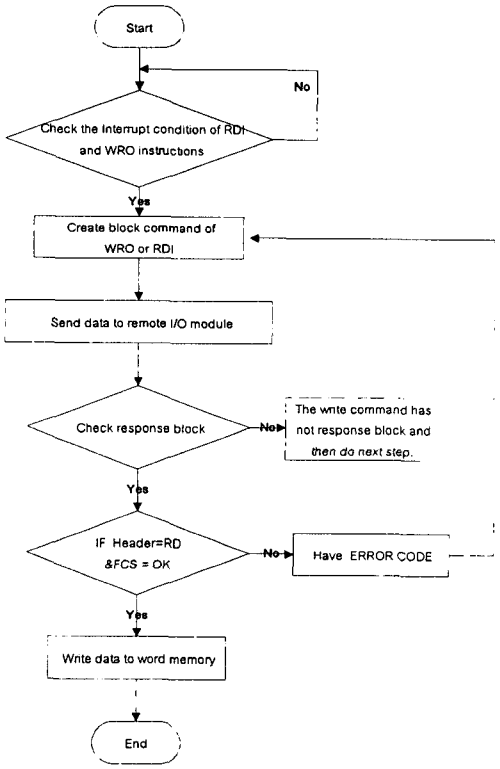

Fig. 7. The flowchart of the WRO and RDI instruction.

When the remote I/O module received the command block, the remote I/O, which is defined by unit number, will send the response block to the PLC. If there is any error occur, the write command will send only the response block to the PLC. The PLC will check the header and the FCS calculations from the read command response block if the error was not found, and the PLC will write data to the word memory.

RDI instruction (FUN70)

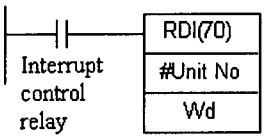

Fig. 8. The RDI ladder instruction.

In Fig. 8, the RDI instruction is the function number 70 in the ladder instruction of this PLC.

WRO instruction (FUN71)

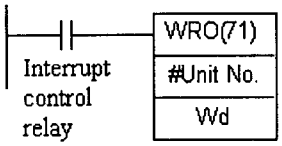

Fig. 9. The WRO ladder instruction.

In Fig. 9, the WRO instruction is the function number 71 in the ladder instruction of this PLC.
Both instructions have to determine the unit number of the remote I/O module, which requested information. The WD is the word memory in the controller as hexadecimal code for 16-bit binary system. The data from the remote I/O should have temporary storage area in the word memory, which is determined. Therefore, the remote I/O memory is considered as the PLC memory. There are many kinds of word memories in the PLC such as Internal Relay (IR), Holding Relay (HR), and Data Memory (DM), respectively.

6. Implementation

This system can be applied to the multi groups' ON-OFF control with long distance (maximum distance 4,000 feet at 100 kbps data transmission rate). In this experiment the 9,600 bps data transmission rate with 500 meters distance is used. The explaination of the operation of the RDI and WRO instruction in the ladder diagram programming is shown in Fig. 10. In the first rung, a technique to generate the oscillator with one scan time is programmed. In the third rung, the PLC will read the data from the remote input module number 00 and write the data to the remote output module number 01 every scan time because of the interrupt control relay number 1001 and 1002 are oscillated. By this technique, the data of remote I/O number 00 and 01 will be stored in HR10 and HR11 and updated data every scan-time. The other remote I/O modules in the network may not work by this program. It depends on the logical condition of the interrupt control relay at the RDI and WRO instruction.

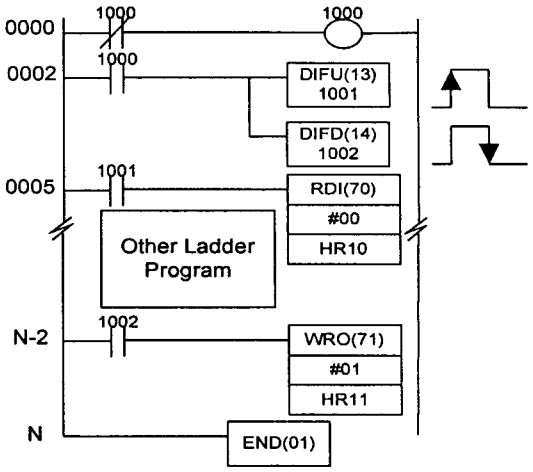

Fig. 10. The example ladder program.

7. Conclusions

The paper shows the technique to design the PLC system inorder to expand the input and output with the remote I/O module. This PLC system can be used to control many devices with long distance as same as the fieldbus technique. The instruction being designed in this PLC is very elastics and suitable for the ladder diagram programming. The PLC can be efficiently applied to the ON-OFF control for the agriculture farm, the building automation, a multi group of control.

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