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A Study of I/O Serial Communication Systems Between Overground And Overhead Controllers

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Abstract

This paper represents the Input/Output (I/O) serial communication methods between overground and overhead controllers using a programmable logic controller (PLC). In general, the systems composed by overground and overhead controllers use exclusive serial communication units. This, however, has a demerit such as a high cost as well as some restrictions of the system itself. Thus, this paper suggests methods by I/O cards for data communication between overground and overhead controllers. In this system, there is no special card and it therefore has a lower cost and is more flexible than the exclusive serial communication unit.

Key Words : I/O serial communication, overground and overhead controllers.

1. Introduction

Among the equipment used in industrial sites, systems such as Stacker Cranes, Traversers, and EMS (Electric Monorail System) transporting an article in midair are composed of overground (main) and overhead (sub) controllers. The former manages movement and data, and the latter controls machine performance.

A transmission route of communication that allows the needed communication of data between overground controller and overhead controller in this system is restricted by both installation and usage. Because of these restrictions, equipment exclusively designed for serial communications such as the Trolleymation or optical communication units are used. However, this special equipment is expensive and is often restricted by the system construction, sometimes requiring exclusive control panels or outlets.

The system proposed in this paper achieves data communication between overground controller andoverhead controller by using an I/O card. Although the transmission speed of this system seems slower, it transmits 16bit data per 0.5 seconds, which does not affect the installation and usage of material handling equipment generally[1-3].

Moreover, since it does not use a specially designed card, it reduces costs and, because it does not rely on hardware, a flexible system can be constructed.

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2. System Construction

Fig. 1 shows the concept of basic construction in the proposed system. As shown in Figs. 1, two PLCs each are connected to one I/O (output/input) point by I/O cards to begin the transmission of 16bit data to each other. A bus bar is used to carry the signals, through which overground controller and overhead controller can communicate data either directly by using the I/O card or by using a photo sensor attached to the control panels for transmission.

Fig. 2 is a model of a connection using a bus bar. Bus bars used in industrial equipment usually have a total of six to nine poles; four poles including a grounding connector are for power sources and two to five poles are for signal-transmission bus bars. The proposed system, whose basic construction is show in Fig. 2(a), is an example of systems that use two poles for signal-transmission bus bars. Fig. 2(b) displays a system in which, like in an EMS, a bus bar loop is divided into multiple sections to which multiple overhead controllers are connected. Fig. 3 shows a connection system that uses a photo sensor. In this case, only four bus bars are needed since electrical power is provided to the overhead controller via a power source. Figs. 3(a) and 3(b) each shows a unitary connection and multiple connections using a photo sensor.

3. PLC Application

Any PLC with a time interrupt and a processing speed that can manage the program and data of the constructed system can be used. This study used GOLDSEC (or MELSEC), which is most commonly used in industrial sites.

3.1 Time Interrupt

Time interrupt is needed because to synchronize transmission/reception and regulate signal rates, regular communication-program operations are necessary. Although it is true that the shorter the time interrupt the faster the communication speed, 10[msec] is used here since the fastest time interrupt is 10[msec] [1-3].

3.2 CPU Processing Speed

When an index command of a bit device for a GOLDSEC MnA is used, the communication program is composed of approximately 600 steps; if the command is not used, the communication program is composed of approximately1000 steps. The processing speed of a 10[msec] time interrupt is approximately 1[m]sec. Because the End process is 3[msec], it is impossible to use a MnN for overground controller to communicate with more than six overhead controllers. In addition, because overground controller must perform tasks other than managing communication, such as moving control of machines, an MnN is inadequate. When an MnN is used as overground controller, the processing time becomes longer compared to the number of steps required because the processing time required for an index command is greater than that required for an ordinary command. Up to 20 overhead controllers can, however, be used [1-3].

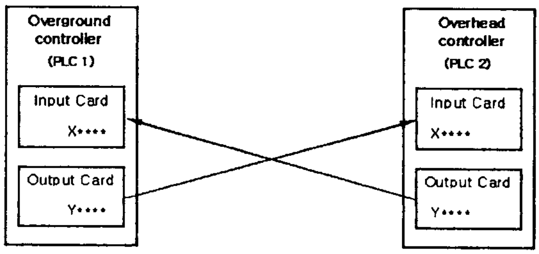
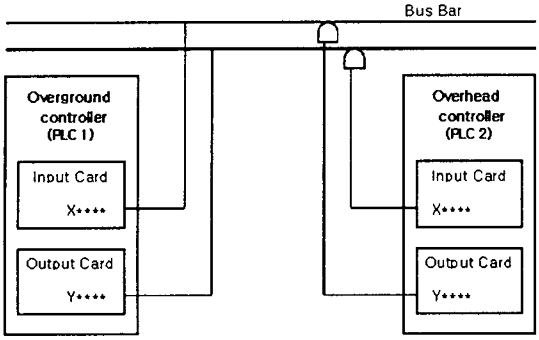
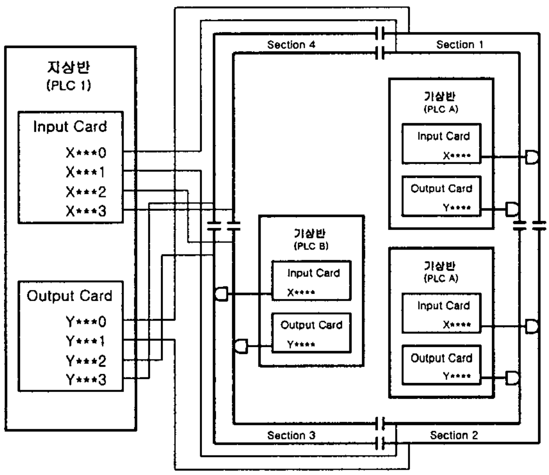


Fig. 1. Basic Construction

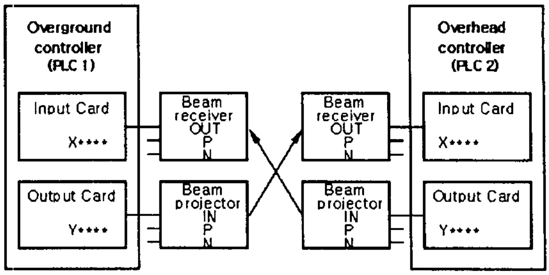


(a) Unitary connection by bus bar

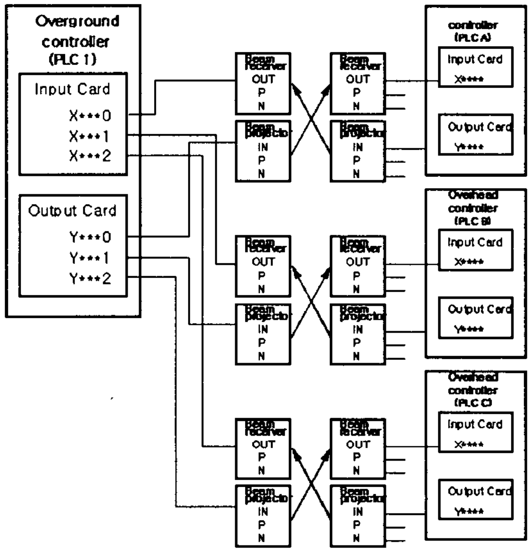


(b) Several connections by bus bar

Fig. 2. Connection diagram by bus bar



(a) Unitary connection by photo sensor



(b) Multiple connections by photo sensor

Fig. 3. Connection diagram by photo sensor

3.3 I/O Card

Because the system processes a 10[msec] signal, it is impossible to use AC cards or an AC sensor considering the response time. Instead, the system requires a high-speed DC input card. As the MnN case shown in Fig. 4, because the End processing speed is 3[msec], data that normally require 10[msec] for transmission can take anywhere from 7[msec] to 13[msec] for transmission. Therefore the noise filter for the input card should be 7[msec] [4].

4. Communication Algorithm

The system presented uses a PWM method to communicate serial data. If a bus bar is used where no additional signal devices are needed, the connection is direct for communication as shown in Fig. 2. When a photo sensor is used, the PLC communication output (Tr type) is connected to the self diagnosis terminal of beam projector and the beam projector is turned on/off to transmit data. To receive data, the photo sensor's receiver output is connected to the communication input (high DC).

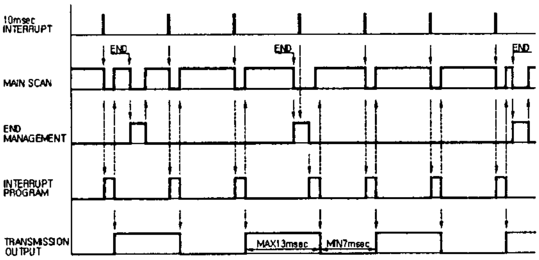


Fig. 4. Interrupt time and transmission output pulse width

4.1 Types of Bits and Pulse Width

There are three types of bits that use communication signal formats as shown in Fig. 5. The pulse width is shown in Table 1. The start/end bit is used to clearly distinguish data. The transmitting end should be 'on' with a continuity of 70[msec] when data transmission begins. On the receiving end, it can be inferred that the start/end bit has been received when the input signal goes off and on continuously for 70[msec].

When the transmission bit is 0, the transmitting end reverses on/off to 10[msec]. When the input signal is reverse to 10[msec], the receiving end will determine that the reception bit is 0. Further, when the transmission bit is 1, the transmitting end reverses on/off to 40[msec]. The receiving end decides that the reception bit is 1 when the input signal is reversed for 40[msec]. The pulse width shown in Table 1 is specifically chosen in order to prevent any misjudgment of data caused by pulse dispersal. In Fig. 4, the End processing timing causes dispersion in the transmission pulse, which also causes dispersion in the receiving end. As shown in Fig.6, this dispersion in both transmitting and receiving ends and the interrupt clock timing can cause the receiving end to misinterpret the transmission of a 10[msec] pulse as 20[msec] or 0[msec]. To prevent such a mix-up of data, a margin of ± 10[msec] should be allowed. Because of this, when the 0 bit is said to be 10[msec], the margin should be 0~20[msec] 1 bit should be 30~50[msec], and the start/end bit has a margin of 60~80[msec]. Thus, because the possibility of a data mix-up can be eliminated by putting a 30[msec] difference between data, 0 bit as 10[msec], 1 bit as 40[msec], and start/end bit as 70[msec].

4.2 Parity Bit and Data types

Where the parity bit signal is 1 indicates an odd parity. Thus, when part 1's number is an odd number, the parity bit becomes 1. The reason only those parts with 1 are considered to be parity bits can be explain by discussion of 4.3 noise countermeasures. As shown in Table 2, the data used in the proposed system transmit/receive a total of four types of data, including two types that require ACK/NAK and two that do not [5].

Table 1. Pulse width

Signal		Trans data ([msec])	Received data ([msec])
"0" bit		10	0~20
"1" bit		40	30~50
start/end bit		70	60~80
Signal 'on' error		-	Over 60
Signal 'Off' error	Receiving data	-	Over 60
	standby	-	Over 90

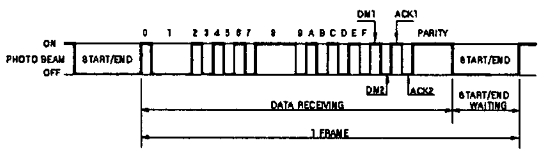


Fig. 5. Interrupt timing and reception recognition

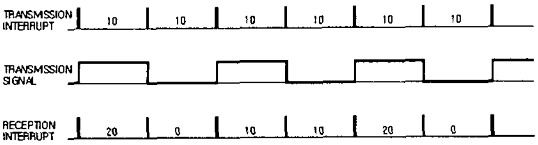


Fig. 6. Data transmission time chart

Table 2. Transmission data mode and data contents

Trans direction	Mode bit		ACK bit		Data contents
	DM1	DM2	ACK1	ACK2	
Overground ↓ Overhead	0	0	-	-	general interlock
	0	1	-	-	Manual operation command
	1	0	1	-	Automatic operation command
	1	1	-	1	No operation
Overhead ↓ Overground	0	0	-	-	interlock
	0	1	-	-	In current location
	1	0	1	-	No operationl
	1	1	-	1	Data errors/ill functioning

4.3 Noise Countermeasure

Because the system proposed uses a photo sensor or a bus bar, noise and other disturbances can cause a mix-up in data. Therefore, the 'on' bit parity is used as a countermeasure. In Fig. 7, when dust or noise changes a 1 bit to three 0 bits, the start/end in standby receives 0 bit or 1 bit. When this happens, all previously received data are cancelled.

Fig. 8 shows the case in which dust or noise caused three 0 bits to become 1 bit. In this case, the input is turned to 'off' when the data being received exceed 60[msec]. As shown in Table 2, when input is turned off due to data reception exceeding 60[msec], this becomes a reception error and the data being received are cancelled.

As in Fig. 9, when the bit increases and decreases concurrently due to dust or noise, checking parity for all bits can mix up the data. Therefore, as shown in Fig. 9, data cancellation is possible by checking parity as 1 when the signal is 'on' and processing it as a parity error.

However, when bit increases and decreases concurrently by the same amount evenly, there is no countermeasure. A regular examination of the photo sensor and bus bar can eliminate this possibility.

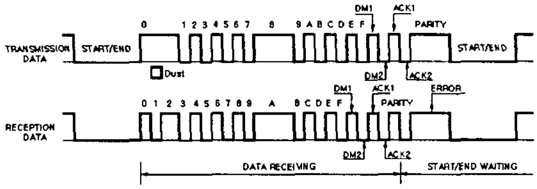


Fig. 7. Time chart of bit increasing

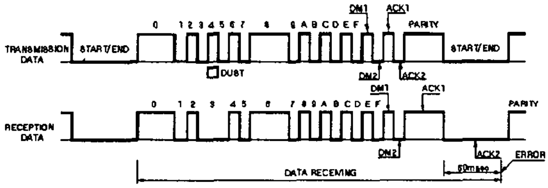


Fig. 8. Time chart of bit decreasing

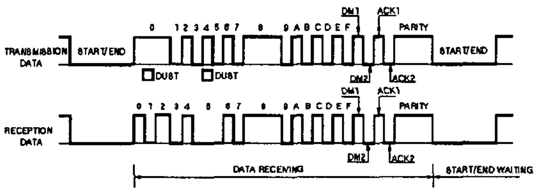


Fig. 9. Time chart of simultaneous bit increasing and decreasing

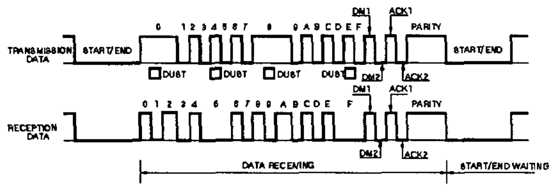


Fig. 10. Time chart of simultaneous bit increasing and decreasing, the same number and an even number

5. Program Construction

The Reception and Transmission programs are completely independent from each other and the reception program is constructed with blocks (functions) as shown in Fig. 11. The Transmission program is constructed with blocks (functions) as shown in Fig. 12[6].

5.1 Functions of Reception Program

The input signal check program facilitates the management of the input of input card on/off condition within the reception program and produces changes from 'off' to 'on', 'on' to 'off' and, current 'on' conditions.

The signal length confirmation processing program determines whether the reception bit is 0 or 1 by counting the input signal 'on' and 'off'' period when there is a change in conditions. This program produces 0 and 1 set demands for 'on' signals, 0 and 1 set demands for 'off' signals, start/end bit reception, 60[msec] 'on' conditions, and 'on'/'off' input errors.

When an 'on' signal 1 set demand signal or an 'off' signal 1 set demand is made, the reception buffer bit set program sets the reception buffer bit corresponding to the reception data pointer to 1.

A reception point count program sets the value of reception point to +1 when 0 and 1 set demands are made during 'on' or 'off' signal.

The parity count program turns a value of an 'on' bit counter into +1 when the 'on' signal 1 set demand is made.

During the start/end bit reception, the data confirmation processing program confirms the data of the reception buffer when the reception point counter is on start/end standby and is in a satisfactory 'on' parity condition. It sets the data area, resets the reception buffer, the reception pointer, and the parity counter, and then begins the next data reception.

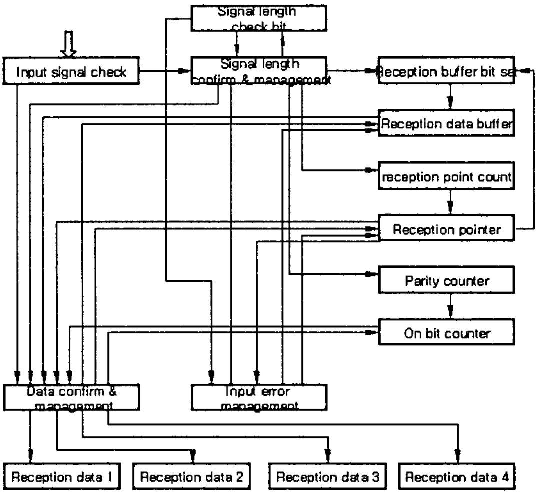


Fig. 11. Reception program

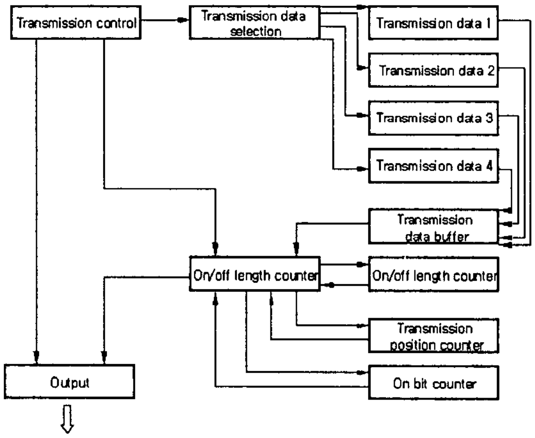


Fig. 12. Transmission program

If the conditions are not satisfactory, it disposes of the data received up to that point, resets the reception buffer, the reception pointer, and the parity counter and begins receiving the next data. In cases in which an input and output error has occurred, the 'on' condition exceeds 60[msec] during the data bit reception, or the data pointer receives data other than the start/end bit during the start/end standby, the input error processing program judges the input signals to be errors and resets the reception buffer and reception pointer. It then waits for the next start/end bit.

5.2 Functions of Transmission Program

Since the function of the transmission program transmitting signal is unaffected by communication routes and conditions, the construction of this program is much simpler than for a reception program. The function of each block that composes the transmission program is described below.

The transmission management program oversees the start/end bits and other data transmission.

The transmission data selecting program chooses the transmitted data and sets a transmission data buffer when the start/end bit transmission is completed.

The bit data program determines the value of the transmission location counter to be +1 when the bit conditions of the corresponding transmission data buffer is 0, and thus 10[msec], and 1, and thus 40[msec], after the start/end bit is completed. When the even bit is 1, the bit counter is denoted as +1 for parity output.

The output program turns output to 'on' during the start/end bit transmission (but not when the bit data is being transmitted) or when the value of the transmission location counter is an even number('off' for a beam projector used by transmission).

6. Conclusion

This paper discussed the construction of a communication system using a PLC I/O card as a replacement for expensive systems consisting of overground and overhead controllers such as Stacker Cranes, Traversers, and EMS, that are constrained by the need for power sources and exclusive panels.

This paper proposed a bus bar and photo sensor as carriers of communication signals, and illustrated how the installation and usage of communication routes is simplified when the discussed method of constructing the system is applied. This system has advantages over the equipment exclusively designed for serial communication such as regards the installation cost. Moreover, since it relies on software rather than on hardware, the system has advantages in maintenance and repair needs. Since the system can be applied to a variety of other systems with minor adjustments, it is also highly flexible.

References

[1] GOLDSEC-M series manual, LS Industrial Systems.
[2] ACPU programming manual (basis edition), Mitsubishi.
[3] ACPU programming manual (commonness command edition), Mitsubishi.
[4] I/O module type building block user's manual, Mitsubishi.
[5] Information & Communication Engineering, Hyung seul Publish, 1995.
[6] AJ71UC24 link unit user's manual, Mitsubishi.

Biography

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Received the B.S. degree in Electrical Engineering from Hanyang University, Seoul, Korea in 1992, and the M.S. and Ph. D. degrees in Electrical Engineering from Changwon National University, Changwon, Korea in 1996 and 2002. From 1991 to 1996, he worked for HANWHA MACHINERY CO. LTD. Since 1997, he has been a Professor in the dept. of Electrical Eng. at the Kundong University.