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The signal connections in robot integrated manufacturing systems

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ABSTRACT

Purpose: The main goal of this paper is that, the robot integrated manufacturing systems are more popular and useful in the industry. Moreover, the communication in those systems might be realized by many different data exchange solutions. Using this kind of solution causes the data exchange incompatibility. This paper deals with different ways in informatics connection of all of the components in robot integrated manufacturing system.
Design/methodology/approach: Incompatibility is a result of usage many different communication systems between components in lathe center. The way of mutual signal connections were the target of researches.
Findings: As a result of scientific work, the universal and compatible informatics connection system of the robot lathe center was created.
Research limitations/implications: The project of the data exchange system is confined to PROFIBUS DP lan.
Practical implications: The result of the researches was developing a technical element choice procedure of the data exchange depending on transport means quantity and system composition in the robot lathe system.
Originality/value: This is a brand new paper, which describes internal systems of data exchange in robot integrated manufacturing system in example of automatic lathe center.
Keywords: Robotics; Mechatronics; Technological devices and equipment; Profibus DP

1. Introduction

The continuous market economy development and the tendency to shortening the product life cycle cause constant incensement of requirements in the enterprise competitive. To assure the manufactured product competitiveness, there is necessary to reduce the production costs and, simultaneously, assure the highest quality of the produced elements, what is very important for short batches. The necessity of the frequent product line changes causes the development in flexible production systems. The robot is a universal transport facility, which is used in integrated manufacturing systems, because of the necessity in assuring automatic elements travel in flexible work centre. A very important feature of robot integrated manufacturing systems is productive component varieties, which create the system structure (working machines, robot, conveyors, warehouses, etc.). The obvious result of such state is informative incompatibility in steering of the control systems, which has influence on the range of possible collaboration between those systems. In every flexible manufacturing system there is possible to select the different streams flowing through particular elements of the system. Besides material and energetic streams, the most important stream flowing through the flexible manufacturing system is information stream [12, 13, 16, 17, 18, 19].

2. The structure of the robot integrated lathe center

The analysis of the mutual signal connections in the robot manufacturing system carried through all of the elements in organizing structure, which consists in two FANUC ARCMate 100iB manipulators [9], collaborating with EMCO Concept

TURN155 numerical lathe with the SIMENS SINUMERIC 840D controller [1, 2, 4, 10] and the FLEXLINK plate conveyor with SEW drive, controlled by MOVIDRIVE INVERTER MDX61B0005-5A3-4-00 inverter (fig. 1) [5, 6, 7]. The flexible lathe center is included in the input and output warehouses, the station to the elements reorientation and the security circuit (light curtains and security mats). Fig. 1 shows the analyzed work center. The robot controllers are provided with system software, the standard 48 channel I/O card (input/output) of the robot and, additionally, 32 input and 32 output digital cards [9] about positive logic with current protection on 0.5A level (AID32D and AOD32D card) [18].

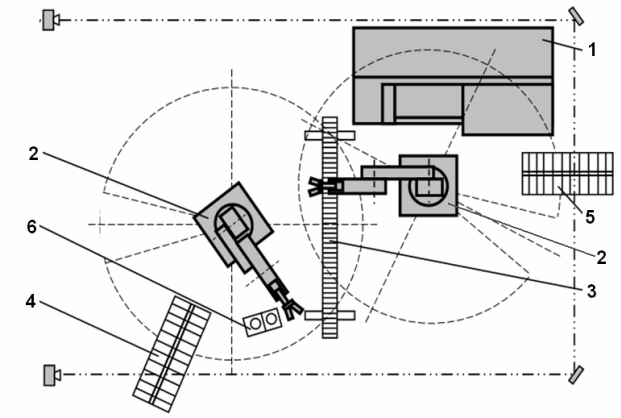

Fig. 1. The robot integrated lathe center: EMCO ConceptTURN 155 (1), FANUC ARCMate 100iB (2), FLEXLINK plate conveyor with SEW MOVIDRIVE INVERTER MDX61B0005-5A3-4-00 (3), input, reorganize and output magazine (4, 5, 6)

2. The data exchanging between CNC lathe and robot

To make the collaboration possible between the robot system and the numerical machine, there is necessary to obtain opportunities of extorting operations, which are connected with the working process. Those operations are e.g. opening and closing the door, closing and opening the lathe chuck jaws and also shifting and removing the tailstock head. The realization of those operations can not be extorted by the working program, but it must be realized as “on demand” procedure by reporting the working machine to operate by robot. For that reason, there was developed an idea to initiating the particular supportive actions with the assistance of the I/O system (input and output card of the robot driver). The simplest way of exchanging information is exchanging the digital signals, therefore there was used the zero-one system (positive logic) to synchronize the steering system of the EMCO Concept TURN155 working machine with FANUC ARCMate 100iB robot. Fig. 2. shows the I/O multi card (EMCO Robot Interface), which is used to realization the information exchange between control system of the working machine and the outer control system of the object which is co-operating with it, and which is responsible for extorting the particular supportive actions of the working machine. The received information about realization of the main program, or also the action of auxiliary machine tool it, is the basis to starting the suitable subroutines of robot cycles. In every time ending of subprogram generates the suitable information the extorting for machine tool by special instructions in the robot program. Because of such signal connection, there is obtained the full work synchronization between numerical machine and robot. The digital input and output card, which is added to the control system of CNC working machine, allows generating the feedback information about readiness for working and loading, defining the working machine coordinate system, opening or closing the door, and also about status of the lathe chuck (open/close). The EMCO Robot Interface card, which is superior to the operator panel of the lathe, enables initiating the reference movements, closing and opening the lathe chuck jaws, closing and opening the door, and also initiating the working program. Through changing the robot digital outputs, connected with lathe I/O multi card, there is also gained switching the lathe servo drive feed on, changing the working mode of the control system to automatic, and also error clearing and setting the feed rate on 0%, what means to stop all of the machine movements [1, 2, 4, 9, 10, 14].

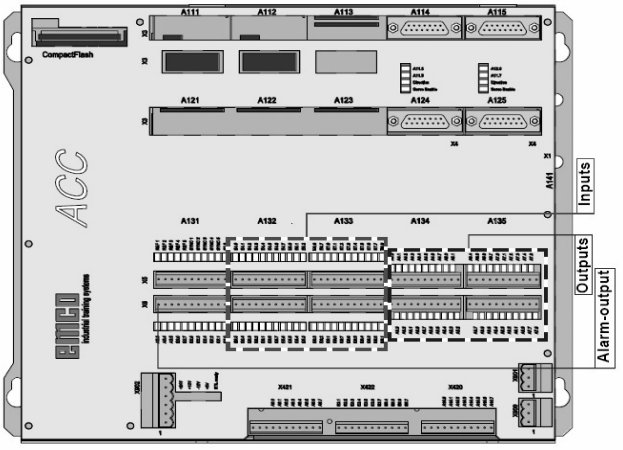

Fig. 2. I/O multi card addend to EMCO lathe control system [3]

To make possible the signal service coming from I/O card of CNC working machine through robot control system, there was necessary to add digital input and output modules to FANUC RJ3iB controller cubicle. Applied additional double input and output modules are shown on fig. 3. The standard 48 channel I/O robot card was designed for initiating and monitoring manipulator conditions in their common workspace area, through signal exchange (condition variables) in robot program between RJ3iB control systems. Digital input and output modules are used for connection security circuits of wiring system, it means for connect light curtains and active security mat. Additionally, digital signals from the object detecting sensor in the input and output. As a result of using binary information exchange system, there was possible to connect EMCO lathe control system and input and output

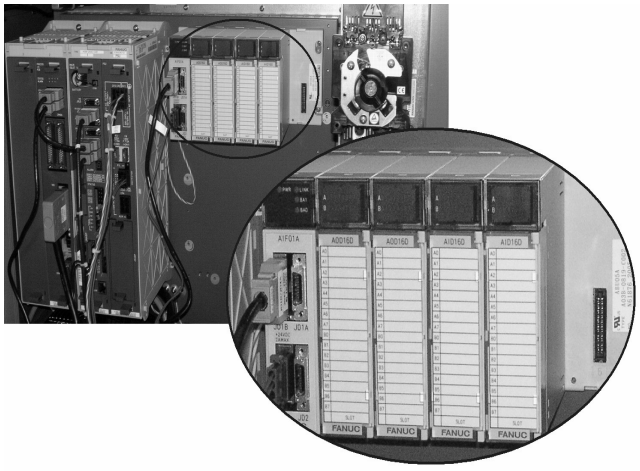

Fig. 3. Digital input and output module added to RJ3iB driver of FANUC robot

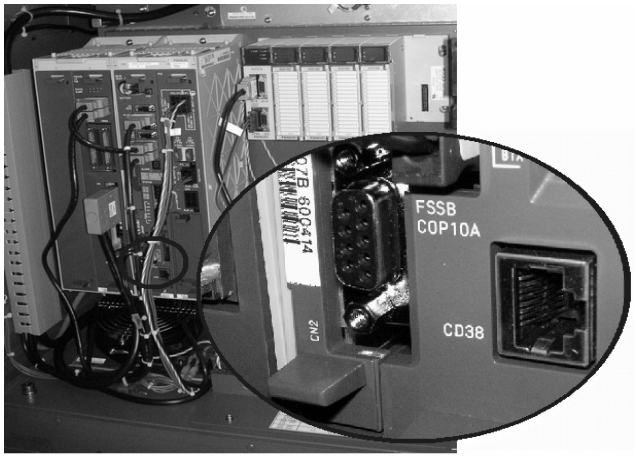

Fig. 4. PROFIBUS DP Master/Ethernet card added to RJ3iB controller of the FANUC superior robot

warehouses with one of the FANUC manipulator control system. For the reason of feed all signals of binary information exchange channel to control system of one of the FANUC manipulator, there was decided to make the RJ3iB controller of that robot superior with respect to remaining components of the lathe work center. Setting one of the FANUC controllers as a superior with respect to remaining components of flexible manufacturing system requires creating robot program, which must link subprograms connected with information exchange, and also with realization the proper manipulation goals. Because the plate conveyor with SEW controller steered by MOVIDRIVE INVERTER MDX61B0005-5A3-4-00 inverter is one of the robot center components, there was necessary to run a transfer protocol between the superior system unit (the RJ3iB driver of the FANUC robot) and the interface of SEW inverter. There was made an analysis of any possibilities connected with usage the inverter transport with other center components, e.g. industrial nets: DeviceNet (CAN) and PROFIBUS DP, RS-485 serial protocol and the transmission by using digital inputs and outputs. It turned out that using the PROFIBUS DP industrial net is universal and, as a result of it, the best solution. To create the industrial LAN there was necessary to add PROFIBUS card (fig. 4) to the superior RJ3iB driver. According to PROFIBUS DP standard there was defined the industrial LAN with one of the superior station (MASTER). The superior station is responsible for reading off the subordinate station (slave), and then processing that information and basis on it, sending instructions in serial mode. To make possible the communication with all SLAVE stations, there was necessary to assign the DP-SLAVE station to the DPM1 station (PROFIBUS DP MASTER first type). The goal of the original PROFIBUS DP industrial LAN configuration is to make possible the collaboration between DPM1 controller and MOVIDRIVE controller of the plate conveyor drive. During LAN progressive development, the RJ3iB controller of another manipulator was connected as DP-SLAVE station.

All operations of mutual collaboration between SLAVE stations and superior DPM1 are set in “OPERATE” mode. Unfortunately, that solution requires that the main lathe working program must contain many subprograms for each machined element, so that the proper steering signal, came from I/O robot system, will run the suitable lathe program by robot. That requirement is connected with the possibility of transfer information in zero-one mode. To make possible the dynamic main working program exchange in working machine and to enable the full service of information flow in the whole flexible manufacturing system by using only one technical element, there was necessary to use PROFIBUS DP LAN [1, 2, 4, 10, 19].

The automatic choice of the working program is realization by connection the direct control bus of the DNC working program (Distribute Numerical Controll) with control lathe system of direct DNC computer with PROFIBUS DP SLAVE card. To make possible creating another computer connection between direct FANUC robot RJ3iB (MASTER) controller and EMCO lathe, there was necessary to add to lathe steering system another computer, which has PROFIBUS DP SLAVE card and installed DNC program in. To assure the possibility of connecting additional systems to computer robot manufacturing center LAN, during configuration the PROFIBUS DP LAN, there was predicted the collaboration with additional PLC FANUC VersaMax controller. The mutual information exchange between PLC controller and direct FANUC robot RJ3iB controller is realizing by feedbacks through DPM1 in “OPERATE” mode. Fig. 5. shows that computer structure in analyzed lathe center. Worth noticing is the redundancy of the information flow paths between CNC lathe and direct robot (MASTER).

This path was duplicated on purpose - to show advantages and disadvantages of using cheaper, zero-one system and more expensive connection – PROFIBUS DP industrial LAN. Using that kind of connection enables working program exchange. Moreover, there is obtained full application of memory registry of the RJ3iB controller.

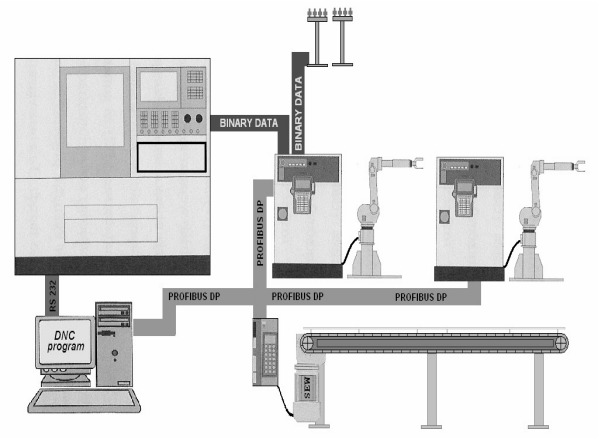

Fig. 5. Computer structure of all paths of information flow in robot lathe center

4. Conclusions

This paper deals with an example of mutual communication solution between all of the components in robot flexible integrated manufacturing system. This issue is complicated and it requires individual approach, which depends on system flexibility. The typical solution of signal communication flow, basis on binary outputs, is simple, easy to use and it doesn't require logical reorganization in algorithm to steering system. It happens so because of the solution simplicity. Unfortunately, using binary data exchange solution makes the complicated tasks realization impossible through individual objects of robot integrated manufacturing system. Using advanced information exchange technology, based on industrial LAN, e.g. PROFIBUS DP, decreases the sending information incompatibility between all objects of robot integrated manufacturing system. There is also possible to use PROFIBUS DP to initializing the supportive operation and sending machining program or only its part to direct numerical computer DNC. To use all possibilities of LAN connections, there is required to change the steering system algorithm, in order to add another object (lathe) to manufacturing center.

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