

## **BRIDGING THE GAP BETWEEN MACHINE AND PRODUCTION CONTROL SYSTEM**

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**Abstract.** *In this paper an emphasis is put on the integration between production and business part of system. In that sense an analysis of methods for the communication between automated technological system (NC machine, automatic production line, etc...) or manual work place and production control information system is given. Connections between production and business part of system are described. Revitalization of an older type of control system using main control board with dual port memory access is shown.*

**Key Words:** *Production Control, Communication Interface, Dual Port Memory Access, ERP Systems*

### 1. INTRODUCTION

After many years of investigation and research, computer integrated manufacturing, in early 20th and late 21st centuries, became reality in contemporary companies. With the integration of subsystems of production system, such as product design, production process design, production planning, production management, etc., and attending to optimize activities in all of this processes, we are making computer integrated manufacturing. The trends toward the automation of processes like Numeric Control (NC) programming, robot programming and planning of production activities are present although those processes were always done by human workers.

Changing process from classic way of manufacturing to computer integrated manufacturing is not completed. Only the first step to the future generation of factories has been made. Following that path the emphasis is put on the integration of functions in manufacturing system. This is also the main problem of the modern manufacturing. Using computers is only a faster, more efficient way to do the integration, if we know how to integrate the manufacturing system so that integration itself is the most important element, and not computer as a tool to do it.

Another important issue is the fact that control and supervisory systems are implemented in a bottom up manner; in contrast to the top down approach adopted by business systems like Enterprise Resource Planning (ERP) systems. The resultant gap in the middle makes it difficult to integrate plant and business data.

In this paper is presented the development of a part of the ERP system with the possibilities of connecting to the control system on the machine level. Also, possibilities and limitations in communication between existing automatic machine control systems as well as other devices into unique integral information system of the manufacturing company are described.

Application of computers in control technique has increased the possibilities and effects of some automatic devices. On the other hand, development of information technologies has helped to increase the level of business activities in factory. Development of computer communication networks enables integration of automatic production machines and business part of system, as well as penetration of different computer technologies. Introduction of new computer technologies is faster in business part than in production part of system. The best example is the application of Programmable Logic Controllers which is illustrated with the little historical digression in the next passage.

In January 1968 Richard Morley from "Bedford Associates" came up with the idea of the first Programmable Logic Controller and manages to realize it. He named it MODICON model 084. Morley used abbreviation PC (Programmable Controller) for this new device [1]. This abbreviation has been used until early '80 when IBM started using the same abbreviation for its personal computers. As the development tempo and application horizons of personal computers were much greater, the abbreviation of computer name became dominant. Contemporary abbreviation PLC (Programmable Logic Controller) was given by Allen – Bradley Company.

According to this, current state in many countries, particularly in transition states, is that in the business parts of system computer technologies are modern enough, but at the factory floor level, control systems may be 20 years and more old. Problems that arise are related to the existence of technological systems of different characteristics, in sense of connection with the rest of the enterprise system, components compatibility, different computer networks and connection protocols, various application software and data structure.

In their quest to drive revenue and cut costs, manufacturing organizations are investing heavily in systems to automate the manufacturing process. This is changing the nature of manufacturing work; thus, manufacturing personnel, now freed from the routine of repetitive tasks, is becoming knowledge workers.

## 2. INTEGRATION OF BUSINESS AND PRODUCTION PART OF FACTORY

A possibility to connect computers within communication networks gives an additional impulse to the integration of business and production part of system.

The latest development in distributed control systems based on PC architecture represents integration of factory data from the whole factory (Enterprise Wide Integration of Factory Data). This trend is in accordance with the philosophy of modern information management which assumes a decreased number of management levels in factory and

greater responsibility for workers in sales, production management as well as in production. Computer network technologies are giving enough possibilities to the realization of this trend and many issues in integration of business computer networks with different levels of industrial control systems are already taking place.

With this linking and data exchange between different applications (for example direct processing of production process data in software packages for analyses in business system) next advantages are foreseen:

- Managers can have a more direct approach to factory floor operations,
- Production planners can use the most actual data on times and production rates so they can easily plan work orders in future,
- Sales personnel can provide realistic estimation on delivery time for customers when they are negotiating new orders, taking in consideration current shop loading,
- Customers who are interested in current state of their orders can be given real information about work completing level,
- Quality control personnel are made aware of real or potential quality problems on current orders, that are in production process, using quality performance data from previous processes in previous orders,
- Cost accounting has access to the latest production cost data, and,
- Production personnel have access to parts and products design documentation so they can do their jobs more effectively.

Development of modern Enterprise Resource Planning (ERP) system named "CAM-erp" is in progress on Faculty of Technical Sciences within the Center for Automation and Mechatronics in Novi Sad. CAM-erp integrates all factory functions and a special emphasis is put on connection of control systems on devices (NC machines, robots, etc...) with work order management system. Some of the problems that are dealt with during that development are shown here.

Effective and efficient management of business and production work processes in industrial systems – enterprises could be achieved via INTEGRATION of functions and processes from top level management to the machine control level. The necessary condition for the proper functioning of an industrial system is defining and realizing relations among all the processes in a completely integrated organizational structure of enterprise and establishing the model of business processes (MBP) in enterprise.

Production control is a management function which plans, dispatches and controls material supply and process activities of an operating production system. Realization of work procedures and material flow control (IPRC) is a production control subsystem that terminates, launches and supervises work orders from the main production plan [2]. Fig. 1 shows the structure and hierarchy of processes in IPRC and logical connections of a module for integration of operation procedures on technological systems and work orders (MP-Integrator) which is used to plan the realization of work operations.

MP-Integrator has been used to takeover programs (NC, robot, etc...) for certain operations, from data base and take them, in electronic form, to control unit of technological system or to tell control unit which operations or which work object needs to be done. An equally important role that MP – Integrator has to do is to transfer data from process and results of work from control unit back to the work order that caused that operation. This

gives feedback between production plan and real execution of that plan which is the condition for the fulfillment of control function.

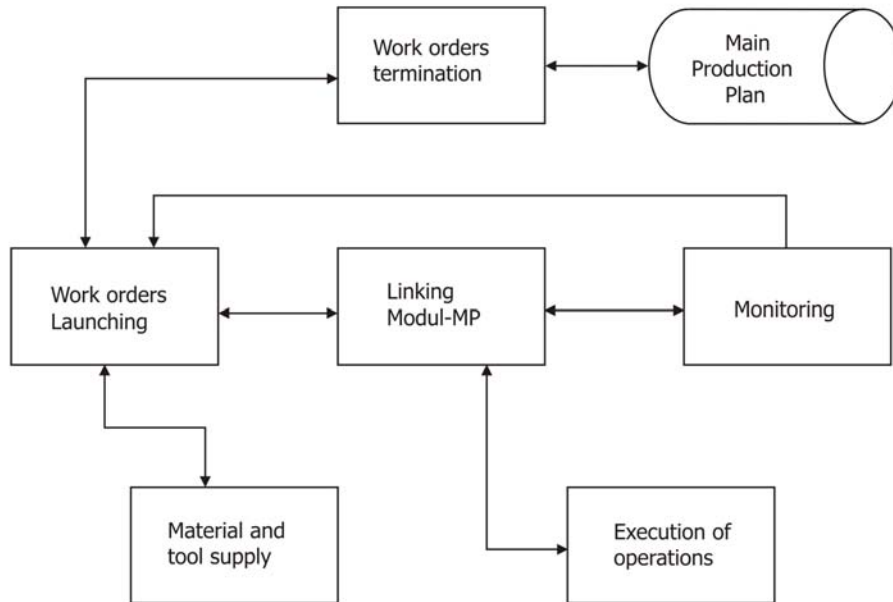


Fig. 1. Structure and Hierarchy of Processes in IPRC Production Control Subsystem

A dedicated solution for the transfer of NC programs on the group of NC machine tools applied in a rolling bearing factory is shown here.

A server is a personal computer (COMPAQ) on which are placed data and where, with a help of software for the management of data base (INFORMIX), is ensured their integrity and consistency.

Work stations are also personal computers connected with the server via Ethernet 100 MB/s net and TCP/IP protocol with help of active components – switches.

Application of module MP Integrator is installed on PC computer and connected via Ethernet with server and via RS-232 with control unit on machine tool. In this particular case, machine tool is two axes milling machine EMAG MSC12 and control unit is SINUMERIK-3. Machine tool, with other equipment and connections between them are shown in Fig. 2.

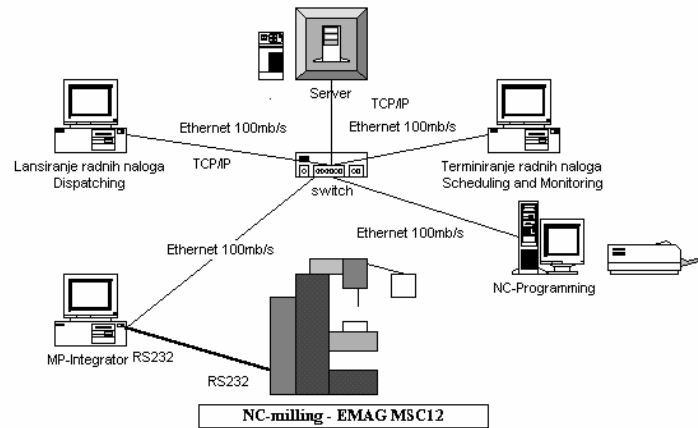


Fig. 2. Example of Hardware Connection of Two-axis Milling Machine in Integrated Information System

A special hardware device is made for the connection of machine tools called two way serial switch which scheme is given in Fig. 3. It is placed on the PC located in the work cell consisting of a group of NC machines. It is software controlled and is able to provide up to 12 serial outputs with which is enabled connection of up to 12 NC machine tools. With this device is possible to transfer one NC program on one machine tool in one particular period. Besides, acceptance and saving of manually corrected programs in G-code which are done by operators on machine tools are also enabled.

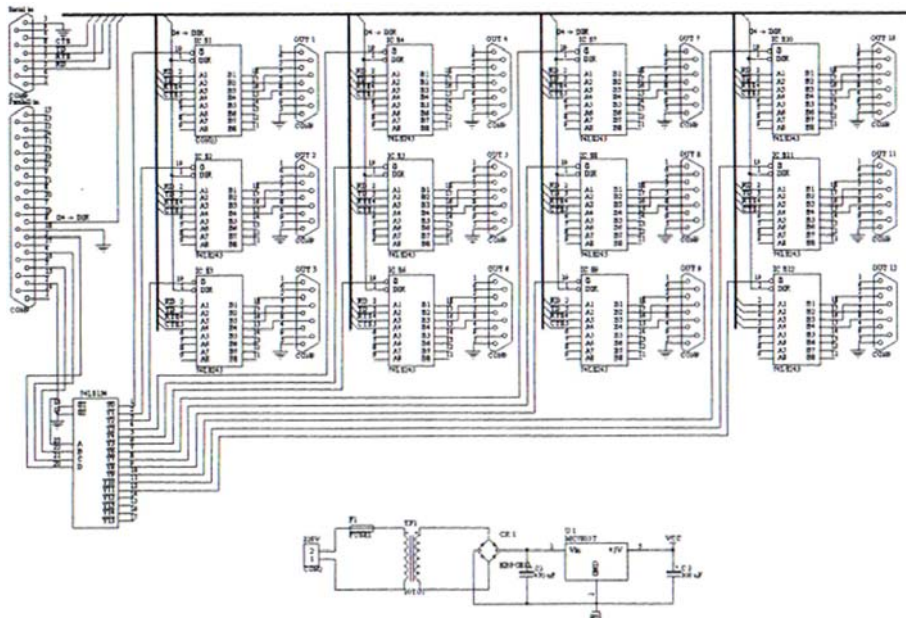


Fig. 3. Configuration of the Main Board for Two Way Serial Switch

### 3. BRIDGING THE GAP IN COMMUNICATION FROM MACHINE CONTROL SYSTEM TO INFORMATION-CONTROL SYSTEM

The existing technological systems in production, no matter if they are manual, mechanized or automated, should be integrated in a unique information-control system. For the integration it is necessary to enable all processes to connect with information-control part of the whole (enterprise wide) system.

When we talk about machines with new generations of control systems, equipped for network communication, it is necessary to adjust hardware and software interfaces with industrial communication network and also to enable integration of that process in integral information-control system that informatically assist to business operations in whole system.

If we take in consideration the automatic technological systems with an older control system lacking an external computer communication which is the case in many manufacturing companies, the integration problem can be solved in three ways:

- Developing special hardware and writing special software which demands a complete approach to the existing control unit in a sense that manufacturer should give all the details about control architecture and communication protocols.
- Adding communication unit to the existing technological system that is independent of the existing control system of that device. That unit allows the workers to enter data manually in a ready-made mask for the reception of data at that added communication unit. After that, the communication device will contact enterprise level information system using industrial communication network,
- Replacing existing control (control system revitalization) with a new control system. During this process, energetic part (electric motors, drivers, etc...) is kept but a new controller that is able to communicate with information-control system in two directions using network is added instead of the old one.

The first method cannot be often realized because manufactures do not want to give that data (intellectual property, patent holding, etc...) and, moreover, even if we get that data, the realization itself is very problematic in a matter of time and money.

The second method is faster to realize because it uses available components and does not demand any development of a new system software but only application of the existing software for that application. It also allows integration of mechanization and manual workplaces. The drawback of this method is that it is not completely automated but it requires the operator to enter data. It is described in chapter 4.

Third method is more expensive than second, but its advantage is that it systematically enables communication as well as it gives a better and advanced automatic control of existing technological system without buying a completely new automatic technological system. It is described in chapter 5.

### 4. ADDITIONAL COMMUNICATION UNIT

The following chapter presents a communication model between information system, SCADA application in business part of company and production machine which communicates using PLC and operators' panel as is shown in Fig. 4.

This model can be applied to the control of filling up of a work order list for the execution of any job on any operation regardless of whether it is an automatic device, mechanized or manual work place. The problem of communication between different parts of the system is solved by getting connected to the existing local industrial Ethernet network that represents an optimal platform for the automation concepts of the future, based on Industrial Ethernet.

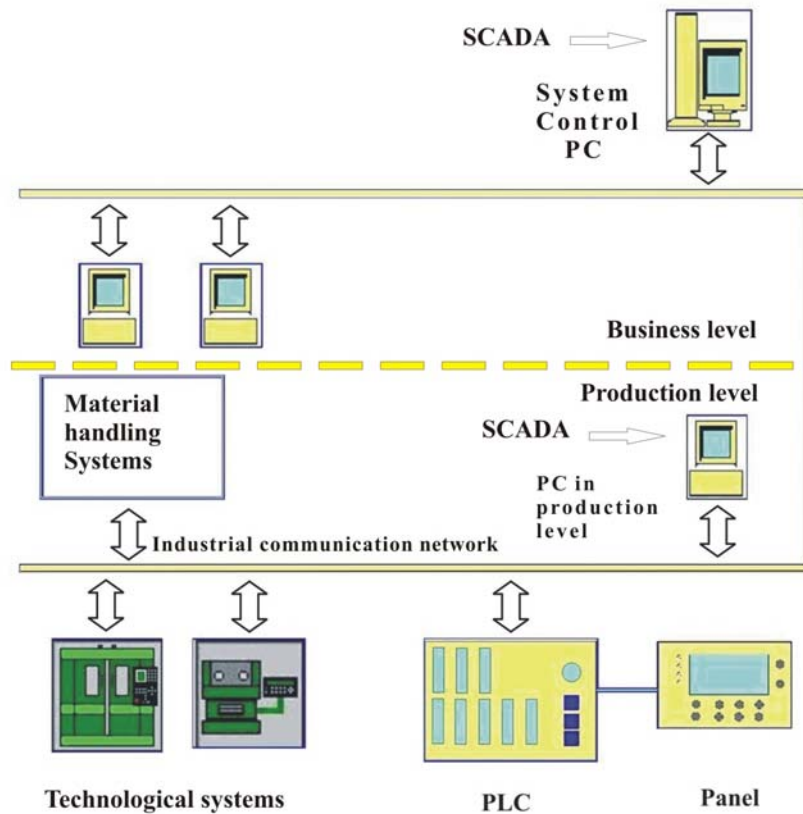


Fig. 4. Structure of Communication between Production Machine and Information System

The system with PLC controller is compact, flexible, reliable and simple for monitoring and service, and due to possibility of connection of controllers with Ethernet, all advantages of networking are used such as greater speed of transferring data than with serial transfer, simple expansion, possibility for connection of various components of different manufacturers and independence of operations from the other components in the network. Expected effects are: a greater degree of integration between business and production part of system, reducing the possibility for losing data from work order list, reducing the time for production cycle and lowering the costs of production.

The operators' panel which is, in this case, used as the second of the three above mentioned methods for the communication with ERP system, represents a human machine interface (HMI) which enables a simpler control of automation tasks. It provides visualization of program sequences and allows operators' access to the controlled system. New generation of operator's panels offers improvements in automated systems and sets new standards in functionality and integration of industrial environment.

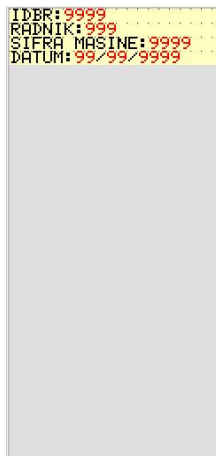
The operators panel provides visualization of values of process variables, status, alarm and messages, input of numerical values connected with the process, diary of errors with time originated – system errors and errors defined through program as well as password protected change of values defined by default, timers and counters and statement of parameters by name or address.

Development of project for the panel is made with some of program packages that can be installed on PC. In that case, hardware of the panel is communicating with the controller and transferring data, enabling the user to concentrate on his job.

Different models of controllers requires different parameters in order to communicate in a proper way with the panel interface so it is necessary to choose a controller type from the net with which will panel communicate.

In the case of the already mentioned rolling bearing factory, the operation panel that has been used is product of Festo Corporation and it represents the newest series of panels with Remote Access Panels. This panel type (Front End Display) offers whole operator's interface which makes access much easier and also provides diagnostics during the operation of a machine beside which it is placed. Complete functional flexibility of the panel also provides a possibility of interaction with Festo IPC FEC Compact or Standard controllers, professional industrial PC machines and pneumatic components. IPC FEC Standard controller is used in the above mentioned network.

Fig. 5 gives a view of one of the forms developed for data input via operator's interface. In the figure we can see that only part (4 rows) of maximum 30 rows is used. This is adjusted to the applied operator's panel that can display only 4 rows. It is possible to choose whether all requested data will enter via one page of the form or (like in this case) they will be divided on several forms that can be called in a sequence.



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IDBR: 9999 .....
RADNIK: 999 .....
SIFRA MASINE: 9999 .....
DATUM: 99/99/9999 .....
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Fig. 5. A Form for the Input of Data via Operators Panel



In a given example for the generation of SCADA application is used ZenOn software which belongs to Microsoft group of program packages and operates under Windows environment. Fig. 6 shows one of the screens of developed application where a group of production machines supervised by this application is shown. Fig. 7 shows a report with the numerical values which SCADA is receiving via industrial communication network from the operators' panel.

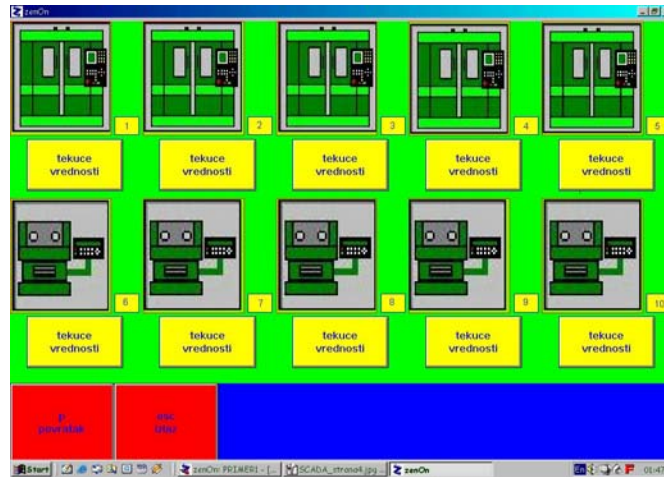


Fig. 6. A View of SCADA Screen Positioned at Server in Business Part of Company

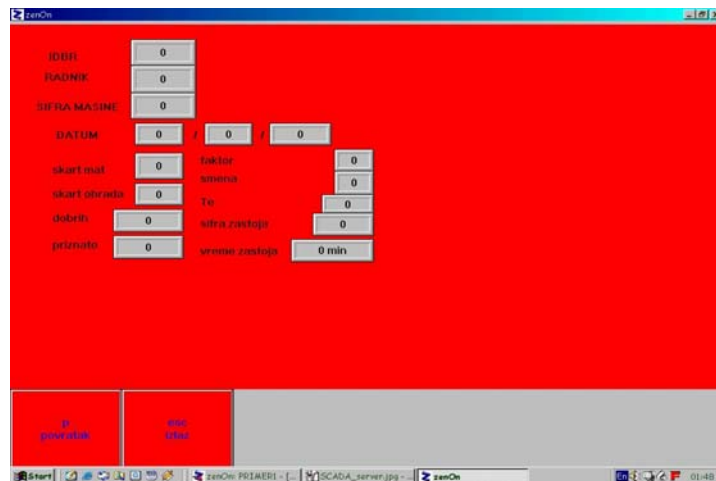


Fig. 7. View of the Values Obtainable for Each Production Machine directly from SCADA Screen

### 5. CENTRAL PROCESSING MODULE OF MODULAR PROGRAMMABLE CONTROLLER WITH DUAL PORT MEMORY ACCESS

Modern control devices for the process industry facilities and modern control devices that are used to control machine tools can be divided according to their functional parts to several interconnected subsystems. Two subsystems are particularly noticed and they are obligatory for contemporary control systems. First subsystem, as is shown in Fig. 8, is a subsystem whose function is control and the second subsystem is a human machine interface.

Control and regulation computer subsystem works in real-time. With its hardware and software resources it is adapted to this assignment. In its structure the dominant part takes resources that enable reaction to the events in environment (developed system for accepting interrupts), time measurement, generating time depending actions or time induced cycle of actions and systems for cyclic transfer of data block in a frame of subsystem itself as well as in a frame of information interchange with the environment. This subsystem usually has units for numeric data processing and communication with the other equipment using particular fieldbus.

In process industry often exists a need for many analogue and digital inputs and outputs. CNC tool machines have an additional requirement for extra modules that enables closing feedback on individual axis. Because of that our realized subsystem has a possibility of expending, enabling adding of new modules. This expending is realized via system bus. System bus does not limit real-time work. Subsystem functioning is under supervision of real-time operation system (RTOS). This operation system refers to events with application dependent reactions on concurrent events. Application program support is in accordance with IEC 61131-3 standard.

The second subsystem has the task to exchange information with operator. From hardware side, this subsystem is equipped with some form of screen and keyboard. Nowadays, thanks to the tools used for the development of this kind of applications, and taking in consideration that this subsystem does not demand any real-time operation in a way that first subsystem does, it is often realized to be compatible with PC.

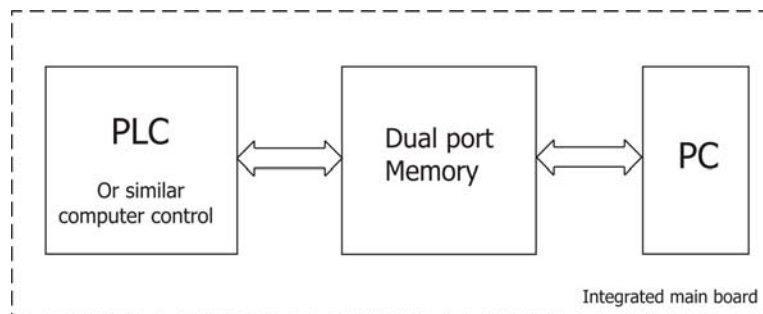


Fig. 8. Principal Structure of Integrated Computer Control and PC with Dual Port Memory Access

The realized system, shown in Fig. 9, consists of two subsystems whose functionality matches the above given description. The main issue in computer control subsystem is 32

bits I80386EXTC microcontroller around which is everything organized. Operative memory possesses 2 MB of battery operated RAM memory and 2 MB of FLASH memories. Operative memory can be expanded to 64 MB. External events can be detected using 24 interrupt lines. Subsystem has one full modem RS232C channel and one galvanically isolated RS232C or RS485 channel. Besides, the system has calendar clock, fast optical communication for expansion of system (expansion that is not located in a given rack), control logic and 64 KB of dual access memory. This dually accessible memory is a shared resource with human machine operator subsystem.

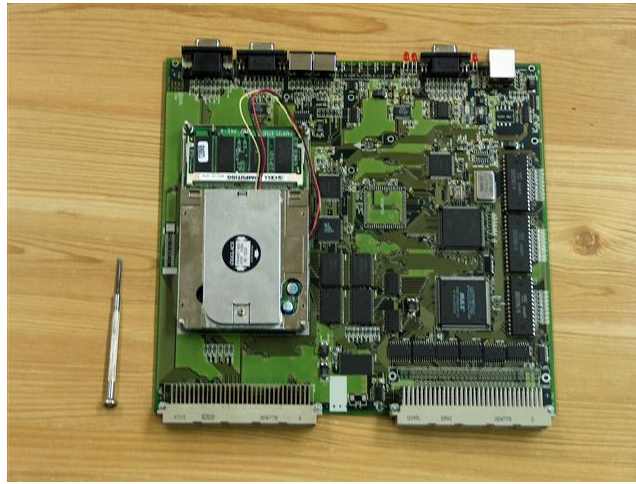


Fig. 9. Realized Control Board with Dual Memory Access

Human machine operator subsystem is completely PC (Pentium II computer system) compatible. This computer system is completely equipped to work in industrial conditions. Besides, screen (CRT and LCD) and keyboard are network-connected, as well as hard and soft disk, printer, mouse, RS232C channel and bus which is compatible with PCI standard. This subsystem enables textual and graphic data display. It also enables usage of software packages such as SCADA.

Using dual port accessible memory, which is operation memory for both subsystems, data exchange between two subsystems is much faster than using any kind of serial communication. Data are available to both subsystems at the same time.

## 6. CONCLUSION

Most of the good manufacturers have already implemented the automation systems they need to enhance production. Future productivity gains would not be achieved via further automation, but by making better use of the information gathered from those systems and from providing workers at every level in the company with a new insight into the manufacturing process to help them make better decisions in real time, from the plant floor production line to the enterprise level.

While a lot of people claim to help users access and deploy data for empowering knowledge workers with "actionable" information they do not extend well into manufacturing environment because the manufacturing world has unique challenges.

This paper gives a short review of problems arising during the integration of information system on the factory floor and information system for the business part of system. In order to integrate all kinds of activities it is necessary to obtain feedback information about the realization of launched work orders.

Three methods for the given problem are stated in this paper and two of them (adding communication unit to the existing technological system and revitalization of control system with the application of main control board with dual port memory access) are described in details.

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## **PREMOŠĆAVANJE PROCEPA IZMEĐU UPRAVLJANJA MAŠINOM I UPRAVLJANJA PROIZVODNOM**

**Dragan Šešlija, Stevan Odri, Zdravko Tešić, Stevan Stankovski**

*U ovom radu je naglasak stavljen na integraciju proizvodnog i poslovnog dela sistema. U tom smislu data je analiza metoda komunikacije između automatizovanih tehnoloških sistema (NC mašina, automatskih proizvodnih linija, itd...) ili ručnih radnih mesta i informacionog sistema za upravljanje proizvodnjom. Opisane su veze između proizvodnog i poslovnog dela sistema i prikazana je revitalizacija jednog starijeg upravljačkog sistema korišćenjem upravljačke ploče sa memorijom sa dvostrukim pristupom.*

*Ključne reči: Upravljanje proizvodnjom, komunikacioni interfejsi, memorija sa dvostrukim pristupom, ERP sistemi.*