

Tomáš LOEBL*, Eva KUREKOVÁ**

NOWADAYS INDUSTRIAL CONTROL SYSTEMS

SÚČASNÉ PRIEMYSELNÉ RIADIACE SYSTÉMY

Abstract

This paper is dealing with nowadays possibilities of machine controlling and steering. In paper is talking about impact of design of control system itself on the process of creating of control software for the system. On the other hand is also talked about symbiosis of machine design and control system design. Paper compares different approach in machine controlling systems. It talks about advantages and disadvantages of different control system. In some cases it talks also about possible application of the system. The result of the paper is overview of nowadays controlling possibilities, their power and possible field of applications. At the end of the paper is described one real application of control system in PCB vertical line.

Abstrakt

Tento článok sa zaoberá súčasnými možnosťami riadiacich systémov strojov. V článku sa hovorí o dopade návrhu kontrolného systému na samotný systém stroja a proces vytvárania softvéru pre riadiaci systém. Na druhej strane hovorí o symbióze návrhu stroja a riadiaceho systému pre stroj. Článok porovnáva rôzne prístupy v riadení. Hovorí o výhodách a nevýhodách rôznych riadiacich systémov. V niektorých prípadoch hovorí o možných aplikáciách riadiacich systémov. Výsledkom článku je prehľad súčasných možností riadiacich systémov, ich výkonu a možných poliach aplikácie. Na konci článku je popísaná jedna aplikácia riadiaceho systému na vertikálnu linku určenú na pokovovanie dosiek plošných spojov.

1 INTRODUCTION

Inseparable part of nowadays machines is control system. Without control system is not possible creation of machine, with capability of sophisticated automatic working mode. We can not even imagine machine without capability of automatic working mode nowadays [4]. Automatic working mode enables increasing of production capacities of a machine at the same or higher production quality level. In this way control system increase quality of the entire production and at the same time by eliminating of human factor failure decrease amount of products that did not pass the quality control. Price of work is decreased by the decreasing amount of wrong products and in this ways shorten the time needed for recovery of finances used for machine procure. By this also definitely increase profit, which is becoming from the machine. So it is possible to say that the more autonomously machine is also more productive machine. Definitely this is true only if we talk about correct autonomy. If the machine works autonomously in way, that it is doing what ever it wants to, it will not improve the quality of production and it will certainly not improve quantity of production. From this reason is necessary to use high quality controlling system with high quality controlling

* Ing., UAMAI, Strojnícka Fakulta, Slovenská Technická Univerzita, Námestie Slobody 17, Bratislava, e-mail Tomas.Loebel@stuba.sk

** Ing., UAMAI, Strojnícka Fakulta, Slovenská Technická Univerzita, Námestie Slobody 17, Bratislava, e-mail eva.kurekova@stuba.sk

software. This software has to use known knowledge's about processes made by machine and also about environment and working conditions of the machine [5].

It is also necessary to become aware of big important of symbiosis between machine and control system design. Only if is connection between design of machine and design of control system is possible to optimize both constructions. Modern control system creates possibility for machines to be simpler. For example it is possible to make kinematics of the machine simpler. In this way is possible to decrease price of construction rapidly. On the other hand is very important to be aware that wrong design of a machine can make design of control system and control software much more complicated and in this way increase price of the control system and also amount of time needed for developing of control software. From this reasons is necessary choose compromise between complexity of the machine and complexity of control system [6].

Nowadays most widened way of controlling the machines is using of microprocessors technique. This technology has developed rapidly. Regardless to the rapid development there are some cases when is more useful to use another approaches. Especially in the case of very fast movement is microprocessor system not fast enough. That means situation when is necessary to stop from high velocity at the shortest possible distance, or for example counting of high frequency sensor pulses. In this cases might not be microprocessor the best choice. In this cases are usually use special control boards, which are directly design for controlling of such a process. The inner construction of these boards is different. These differences become from different requirements on the boards.

2 LOGICAL CONTROL SYSTEM

One of the possibilities how to solve quick processes is using controlling with help of logical units "and" and "or" or by Bool's algebra. This technique is not remarkable by the simplicity of implementation or capabilities, but the speed of processing of incoming information is one of the best. When you use proper construction it is also possible to create some form of "memory". In other worlds it is possible to react on the events also according to previous events. This is usually more common for microprocessors control systems. Logical systems are also interesting because of their price. In case of prototype production is price for developing too high so they are not very useful. In case of big series of products is situation completely different. In this case finances needed for developing of system are divided into the many products. So the price of the system is much more reasonable and in many cases better then price of microprocessor system.

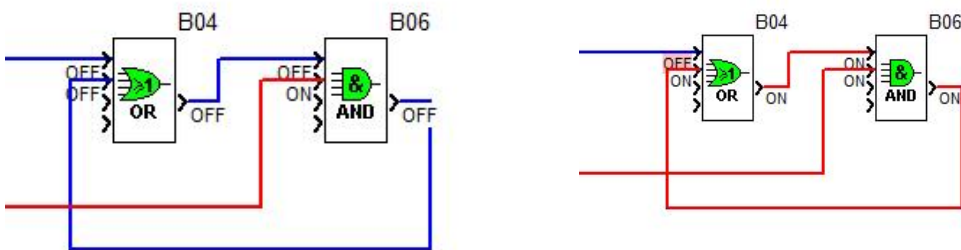


Fig. 1 Example of memory functions in logical control system

3 MICROPROCESOR CONTROL SYSTEM

In case of controlling complicated movements or processes are not possible to use simple logical control system because of growing complexity. In these cases is necessary to use control system with microprocessor. Microprocessor can perform big amount of operations in small portion of time. Than programmer have to use these operations in most suitable way, for completing tasks

required by control system. Situation is not as easy as it seems to be. In microprocessors technique exist many different types of control systems. These systems are different in way of using and also in their purpose.

In case of production in big series is really good to thing about creating of own controlling system capable of programming directly in assembler or possibly in C language. Unfortunately this solution has some big problems. The main problem is maintenance of the system and delivery of spare parts for the system. From this reason is this solution recommended only in production in big series. In other cases is more recommended to use standard control system from established producers like SIEMENS, MITSUBISHI, ADVANTECH and so on [1], [2], [3]. These producers can guarantee quality of their products and also they can guarantee delivery of sufficient amount of spare part for time long enough. In production range of these companies are many different types of control system and control solution.



Fig. 2 PLC control system [3]

Base for many industrial application are controlling system so called “PLC”. Their most outstanding feature is guaranteed time of one program cycle. From this advantage is becoming also their biggest disadvantage. This disadvantage is limited amount of operations that can be inserted into the program. Next problematic feature is process of visualization in these systems. Visualization in these systems is usually solved by using of different types operator panels or by different superior systems. Next problematic thing is necessity of using programming software supplied by the producer of the control system. However this could be also considered advantage. That’s because on the one hand this fact can limit your freedom in programming, but on the other hand this solution secure functionality of programming software.



Fig. 3 Operators panels from company SIEMENS [1]

Another way how to implement control system is to use computer with real – time operating system. That means using of operating system with very small reacting time. Real – time operating systems are for example “Free Dos”. It is operating system similar to DOS. This system has not graphical interface. It has only console. That is so to get the best possible performance. There is also

possibility of using operating system with graphical interface. Such a system is for example Linux or Windows. In this case programmer has to calculate with bigger response time of operating system. We can say that one operation cycle of the program without any machine controlling instruction under the Linux operating system will take approximately from 6 to 25 ms depending on system operations (Invoking of other windows or minimizing them). In system Windows XP is this time also approximately 6 to 30 ms, but when system redrawing screen or window the cycle time jump to 80 to 90 ms or more. In case of operating system Windows CE 4.1 .net is time of the program cycle from 2 to 10 ms, but once for the time system make a longer cycle. This longer cycle has approximately 100 ms. Disadvantage of operating systems with graphical interface is bigger response time. On the other hand advantage is easy implementation of graphical interface into the controlling software. So in processes where response time of control system is not critical feature is possible to use such a system for controlling of machine and also for implementation of graphical interface.

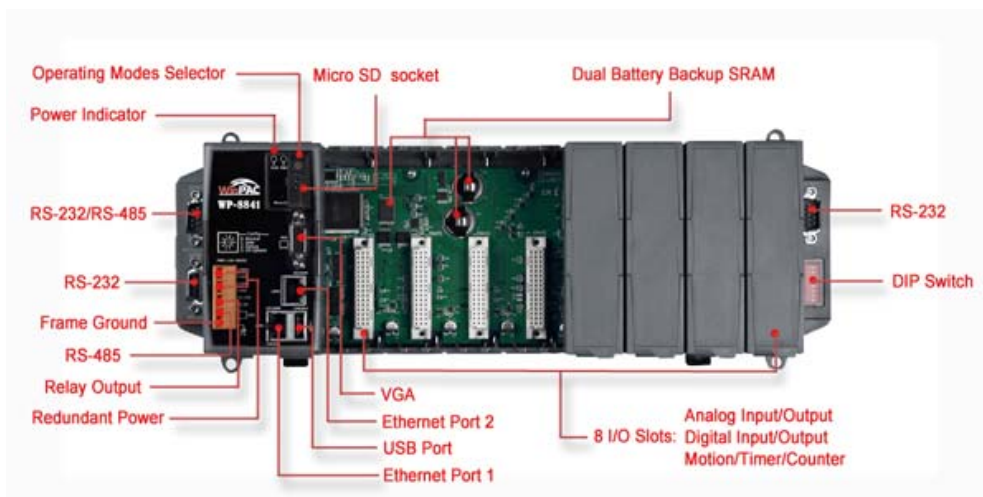


Fig. 4 Control system with real type operating system [2]

Another necessity in the case of computer controlling systems is attaching of output input bus to the control system. General part of producers supplied bus systems. These bus systems usually communicate with computer by serial interface. From this reason is important to add time needed for communication with bus to the response time of the system. So generally if I use bus which can read in one communication packet 64 bits of information's (64 inputs or outputs) and have one start character and one control character It means that the whole communication packet will has length of 10 bytes. That mean that only sending of response telegram at speed of 115 200 bauds will take approximately 0.7 ms. To this time have to be added response time of bus and time of sending request telegram to the bus. So the total time of communication on the bus with 64 inputs or outputs will take approximately from 1 to 2 ms. With increasing number of inputs and outputs at the bus is also the time for communication with the bus increasing. To avoid this problem is possible to use special bus type systems. These systems communicate with bus in internal controlled cycle. In this cycle control board communicate with the input and output boards and map their state into the memory of the communication board. For example system "Frnet" can handle 256 digital inputs and 256 digital outputs in time term one ms. We can say that response time of this system is practically immediate (in micro seconds) because state of the bus is mapped directly in the memory of the communication board and from this memory can be easily read.

4 MULTIPLE LEVEL SYSTEM

In many industrial applications is coming together request contrary to each other request for complicated graphical interface, which make possible handling of very complex control systems and

the request for controlling of quick movements or processes. In some cases also continuous processes have to be handled. This state arise often also in machine tools. Complexity of the machine tools control system is rising with rising of complexity of machining processes itself. Without graphical interface will not be possible for operator to set up a big amount of parameters needed for correct machining of produced parts. In this case are often use combinations of two computers or computer with PLC board or “soft PLC” system.

Soft PLC is software tool, which can be used for simulation of PLC at the computers. Part of processor time is reserved for simulation of PLC system and the other part is designated to the operating system. In this case in simulated PLC is running control program for controlling of machine and at the operating system is running visualization program. This capability has for example Soft PLC system from company SIEMENS.

Another possibility is to use PLC board which can be inserted into the PCI slot of the computer. In this case is control program of the machine running on the PLC board itself and so the process time of processor is going only to the operating system. From this reason is possible to place on the computer visualization program with greater hardware requirements. In both these cases is possible to have only limited number of PLC boards or only one soft PLC on the one computer. According to the number of PCI slots in the computer is possible to have 1, 2 or 3 PLC boards in one computer. On computers with special mother boards can be used bigger amount of PLC boards.



Fig. 5 Industrial computers from company Siemens [1]

This problem can be solving by using of control system with more levels of controlling. It means that there is one control computer which control through the bus or buses different PLC systems. Advantage of this is that is possible to place PLC systems directly to the place where is controlled process. This makes cables to the control system shorter and also reduces the time of wiring of the system. This distribution is also possible in above mentioned system by using of distribution bus system. This variation is from side of system power and number of possible inputs and outputs most profitable. It is also very interesting by the price of the system.

There are also some other advantages when is used standard computer. We can count to them possibility of communication with outer environment through the standard hardware resources like Ethernet. Thanks to this it is possible to connect control computer directly to the company network and monitor work of the machine remotely. This capability is of course possible also with other systems, but in case of standard computer it is standard function that can be controlled by ordinary computer net administrator without any special knowledge about industrial control system. This is

not entirely true in other cases because in other cases special operating system is used in control system. Also there is no problem with spare part supplies.

From these reasons is very profitable use such a two level system in machine tools. The lower level of control is controlling movement of moving parts of the machines. By the speed of the lower system is secure precision of positioning of the moving parts. The upper level control system calculates track and correction of the track. Then through the bus send needed information to the lower system. At the same time thanks to big hard drive enable possibility of storing of big amount of information's and also enable storing of different prepared programs and different parameters of controlling software.

5 PRACTICAL APPLICATION

One of the practical applications of two level control systems is controlling of vertical PCB (Printed Circuit boards) lines. These lines are from two main parts. One part is assembly of tanks. These tanks are filled with process liquids. In some tanks is also add heaters, filtration unit and also airing. In rinses are valves for opening of inlet for water. Second part of the line is transport system. This system is used for transferring PCBs from one tank to another.

Whole system is controlled by one standard computer with PCI communication board. This board has two communication ports. They are combining and can be set as RS 485 or RS 422. One port is used for communication with input output bus. This input output bus is used for controlling of pumps valves heaters and so on. The second communication port is used for communication with another control computer.

This second computer is used to control the transport system. Because transport system has to be fast and accurate control system of transport system has also be fast and accurate. From this reason is on the second computer used real-time operation system and control program has shape of console application. That is because console application is much faster than windows form application. It is because console application does not need time of processor for proceeding of window graphic.

In this way system has reliable reliability and good enough performance to handle the task of controlling whole machine.

REFERENCES

- [1] WWW.SIEMENS.COM at 25 of September 2008.
- [2] WWW.ICPDAS.COM at 25 of September 2008
- [3] WWW.MITSHUBISHI.COM at 25 of September 2008
- [4] DORNER, J: Multiagentové systémy zamerané na riadenie mobilných robotických systémov. In: AT&P Journal. - ISSN 1335-2237. - Roč. 14, č. 12 (2007), s. 94-97
- [5] KOČÍ, P. *Výpočetní technika*. VŠB-TU Ostrava, 1. vyd. Ostrava, VŠB-TUO, 2007, 240s. ISBN 978-80-248-1515-2.
- [6] WAGNEROVÁ, R. Robust Control Verification. *Sborník vědeckých prací VŠB-TU Ostrava, řada strojn*í r. LII, 2005. č. 2, příspěvek č. 1563, s. 231-236. ISSN 1210-0471. ISBN 80-248-1211-8.

Acknowledgement

The results in this paper were made with help of project VEGA 1/0265/08 which is supported by Ministry of Education of Slovak Republic.

Reviewers:

prof. Ing. Vladimír Vašek, CSc., Tomas Bata University in Zlín

doc. Ing. Ondrej Líška, CSc., Technical University of Košice