Microprocessor Automatic Control System for Control of Physics Plants Parameters

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Abstract

A universal modular system for control of physics plants parameters is presented in the paper. The developed system is especially intended to expand possibilities of old operable distributed data processing control systems. The system can greatly increase the performance of data processing without high cost. This effect is achieved by application of the new approach to the object control and to the synchronization of peripheral devices. As the result, the dataflows in the fieldbus of the system significantly decrease. The developed system is particularly suitable in the cases there the narrowband communication channels are available, such as telephony. This paper describes in detail the essence and distinctive features of the applied control method and presents an example of application of the system in the experiment of thermonuclear plasma synthesis. Also we give here the main characteristics of the system.

1 Introduction

The automatic control system was specifically developed for thermonuclear research. Because of universality and expandability, it can be used in any large experiment where the fast synchronous control on a base of many parameters is required. Let's illustrate the operation algorithm of the system by way of example of its operation with our physics plant.

As the object of automation the plasma synthesis plant (see fig.1) is a closed chamber, filled by composition of different gases. The most significant properties of plasma, such as its lifetime and stability, depend on how precisely the composition of gas medium is maintained inside the chamber. During its lifetime plasma exhausts a part of original gas components and we must continuously regenerate these components. The energy emitted during the thermonuclear reaction is partially absorbed by the gas medium and can change its chemical composition. Also one must change forcibly the composition for control of plasma parameters. The theory that would describe the behavior of gas medium and could precisely calculate the optimal control mode is very complex and it can not yet be completely developed. Therefore for plasma stabilization we can use only empirical data.

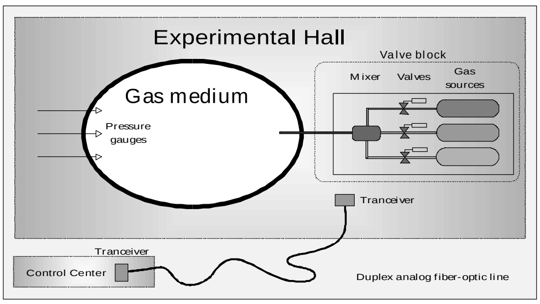

Fig.1. Schematic diagram of the plasma synthesis plant

As shown in fig.1 for control of gas medium parameters blocks of gas valves are used (each block consists of up to 16 gas valves). These blocks bring gas medium components in the different parts of plant work chamber. For checking of gas medium condition the set of pressure gauges is used. The valve control is accomplished by applying of high analog electric voltage to the valve drives.

Experimental data show that when regenerating of the gas medium is absent, the lifetime of plasma is about 10 ms. During this time plasma goes through the several stages of its life; for each stage the distinctive specific composition of gas medium is inherent. Always the plasma conditions don't significantly change during the time interval of 1 ms or less. That's why we decide to make the period of control signal equal 1 ms.

Taking into account the large amount of control valves and necessity of data receiving from the pressure gauges simultaneously with control of valves, the overall amount of data, transferred from the control computer appears to be quite large (it's about 80 kbytes per second). At the same time we cannot use any data channel between the central computer and the plant but analog data acquisition optical fiber line that provides safe transferring of digital data at a rate lower than 2.4 kbits per second. This contradiction forced us to start the development of the new system.

Taking into account the possibility of system expansion necessity of searching for a new object control strategy becomes evident. This method should allow to reduce the amount of information. We have found two such strategies.

1.1 Method of preliminary transferring.

If during the experiment one observes how the pressure of one or another gas component is changing in time, the typical forms of time dependencies that are shown on fig. 2 appears there.

The theory (so-called theory of experiment planning) exists, that allows to predict before the experiment begins how, by what rules we must open gas valves during experiment. The typical forms of control functions are presented in fig. 3.

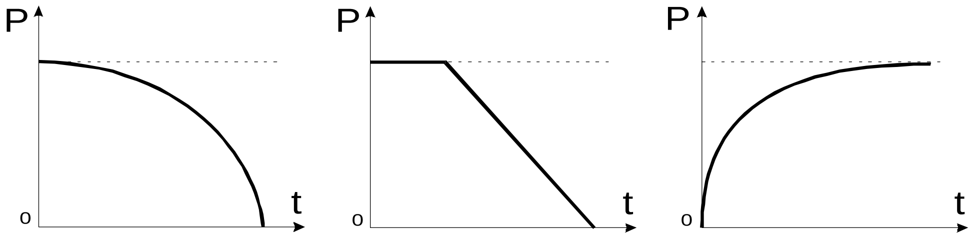

Fig. 2. Typical dependencies of gas component partial pressure on time.

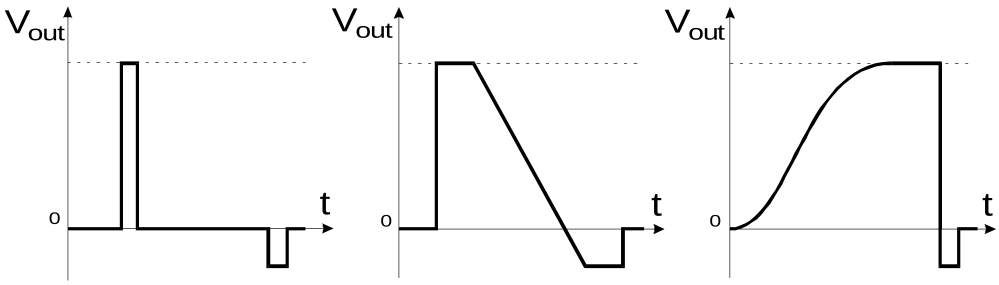

Fig. 3. Typical forms of control voltage on time.

The zero moment on figures corresponds to start of experiment and start of plasma lifetime.

The Method of preliminary transferring is based on the transferring of control image’ through slow data channel into a buffer memory before the experiment starts and on output of this ′image′ in real time during the experiment. For this a microprocessor module with buffer memory must be installed near the plant, the possible structure of that presented in fig.4.

Preliminary transferred ′images′ of the control are placed into the buffer memory as arrays of digital data. Before the experiment the central computer sends out to all peripheral modules the command ′get ready to start′. After execution by all modules of this command any change of the voltage level in the fieldbus starts an output of control ′images′ to the gas valves. At the same time the synchronization of internal clocks of peripheral modules with the central clock of the system is occurred.

Notice that the evident disadvantage of this method is the finite time of experiment, dependent on the size of the peripheral buffer memory. This disadvantage can be removed by using the next method.

1.2 Method of alternated ¢images¢

For this method to be realized, we must slightly complicate the structure of peripheral microprocessor module (see fig.5).

Now in each of peripheral modules the two microprocessors with the device of buffer memory page control are installed. The first microprocessor continuously executes output of control ′images′ to the digital-analog converters, and second processor controls the first by substituting parts of the ′images′ to it from the image library. For simplifying of work with data arrays the buffer memory is divided into pages, which the special device-page selector-moves and swaps in the address space of the first microprocessor. The second microprocessor also provides the data exchange through data channels.

In this method the complicated function of the control process is divided into the simplest pieces (see fig.6), the form of control action in which can be derived from the standard library. This library may be formed by calculating on the base of current condition of the object of the optimum control. The calculation may be performed, for example, with the theory of experiment planning.

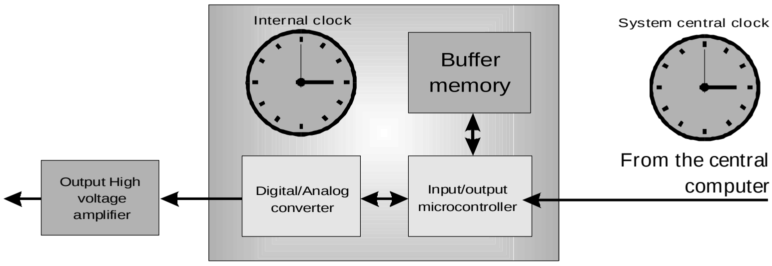

Fig.4. Schematic diagram of the simplest peripheral microprocessor module.

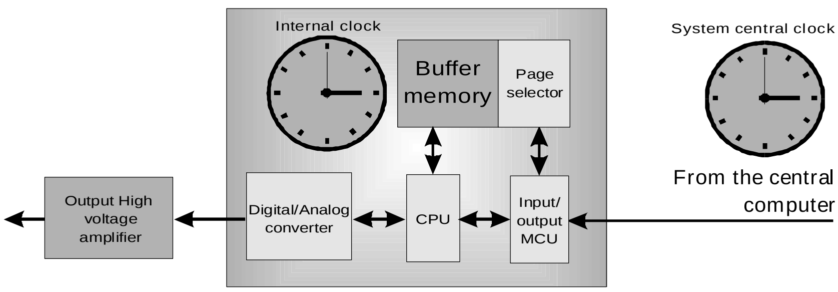

Fig.5 Schematic diagram of the peripheral microprocessor module.

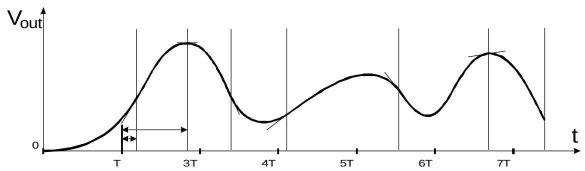

Fig.6. Division of control process into simple elements.

If the size of the library ′image′ is presented by N signal samples, then amount of information, transferred through data channels, is reduced by N times. Moreover, from the current condition of the object one can define further control even of valve blocks (see fig.1). Thus in this case the data rate is reduced by N•m times, where m- the amount of valves in a block. Typical value of N is 1000, and m is 4. Then, for 16-bit control of 32 valves data rate will be equal

$$2002_{byte\ /s} * \frac{32_{valves}}{1000_{samples} * 4_{blocks}} = 16_{byte\ /s}$$

This is more than enough even for very bad data channels, for example for connection through old telephony.

Notice, that in this method signals of peripheral clock synchronization generate in the moments 0, NT, 2NT, and so on. If peripheral module clocks are fast, its microprocessor extrapolates the output signal by using a special prediction table until the signal of the clock synchronization will appear. By this way the precise synchronization of all peripheral devices in the system is achieved.

2 System hardware

The sample of microprocessor module was developed and tested by us. It has the following characteristics:

- Central processor - Zilog Z80 with clock frequency 8 MHz;
- Size of the buffer self-power memory - 128 Kbytes;
- Microcontroller of input-output channel - Intel I8751;
- Amount / resolution of the analog output channels - 20/10, expanded up to 40/10;
- Amount / resolution of the analog input channels - 8/10, expanded up to 16/10;
- Amount of the digital object control data lines - 120;
- Sampling interval of the output analog signal- 1 ms;
- Data rate in the channel between the module and central computer - 300 bytes/s;
- Period of the clock synchronization signal - 1s

The microprocessor module is manufactured as block of standard dimensions and can be mounted into a tower case. There are a mini keyboard and LED display on the front panel. On the back side connectors for gas valves amplifiers, analog gauges of pressure, external digital devices and central computer data channel are placed.

3 Summary

A universal control system was developed, that can use all the possibilities of narrow band data communication channels by the way of the new approach to object control. The example of system peripheral microprocessor module was manufactured with its software. It was tested in our laboratory and may be recommended for using in a physics experiment.

References

[1] Azizov E. A., Koltsov I. M., Rybin V. M. The microprocessor-based system for exploratory physical installations control. Pribory i systemy upravlenya, 1997, no.1, p. 25-28.