Modules for adaptive process control for the M68HC08 microcontroller.

Abstract: The modules for adaptive process control for Motorola M68HC08 microcontroller were created. New modules were converted and optimized from the previous ones originally developed for Motorola M68HC11. These two microcontrollers are not compatible. So programs or modules for M68HC11 cannot be run on the different microcontroller family represented by M68HC08. This work is a part of the project focused on adaptive control and modern methods of automation.

Key words: M68HC08, M68HC11, microcontroller, adaptive control

1. INTRODUCTION

Single-chip microcontrollers are widely used in technological process control. They are cheap, powerful and fast enough for this purpose. Every part that is placed on chip can be used in process control. Analog-to-digital converters, binary inputs or outputs, serial peripheries or timers are embedded directly on chip.

This project is focused on two different and incompatible Motorola microcontroller families M68HC11 and M68HC08.

1.1 M68HC11 overview

The M68HC11 is one of the most widely used microcontrollers in technological processes.

The eight-channel analog-to-digital converter with 8-bit resolution or base interface for serial communication is situated directly on chip. This microcontroller contains two 8-bit accumulators A and B. They can be used as the one 16-bit accumulator D. Two index registers IX and IY are 16-bit large. (Dostalek & Vasek, 2004)

1.2 M68HC08 overview

This microcontroller family is more powerful and optimized for programming in C language. There are similar peripheries on chip. M68HC08 contains 8-bit analog-to-digital converters even the interface for serial communication. However there is only one 8-bit accumulator and two 8-bit registers X and H that can be used as the one 16-bit register. M68HC08 doesn't have external address, data or control bus. (Dostalek & Vasek, 2004)

1.3 Programming of microcontrollers

Microcontrollers are commonly programmed by assembler language or by special application based on C++ that is called Code Warrior. This work is focused on the improvement of the programming process. The library of modules for process control brings many advantages for programmers. These modules might be easily added to the program which improves the programming productivity. The programmer do not need to have deep knowledge in process controlling.

Both of mentioned microcontroller's families can be used with different process controlling algorithms. This work is focused especially on adaptive and self-tuning controllers.

Base modules for regulator synthesis, for auxiliary calculations and for adaptive control were developed at our faculty. These modules were built and optimized for the M68HC11 family and for utilization with operating system RTMON. (Dolinay, 2002)

The first problem is in the transformation of the source code of previous modules to the completely different one that is used in M68HC08 programming. This can be provided by special application developed at our faculty. The converter can automatically translate source code from M68HC11 to M68HC08 (Dostalek & Vasek, 2004). It contains many optimization possibilities; however, the source code can be also reduced by hand.

The second problem is memory. M68HC08 microcontroller family has small amount of memory. On the other hand for example the continuous identification needs quite large space of memory. In connection with various auxiliary calculation and regulator synthesis many of microcontrollers of this family are not suitable.

2. METHODS

2.1 System identification

Real processes are mostly stochastic, so that they are not unchangeable. Theirs parameters are changing over time. Common controllers with fix parameters cannot response to the change of the system. Therefore the adaptive control is used. Parameters of the system are continuously calculated and the regulator parameters can be change during control process. (Bobal et al., 1999)

The block diagram of the controlled system with continuous identification can be seen on Fig. 1.

[FIGURE 1 OMITTED]

The method of smallest squares was used for identification according to (Bobal & Chalupa, 2003). The system was identified in the following form:

$G_s = Y(z)/U(z) = B(z^{-1})/A(z^{-1})$, (1)

where:

$A(z^{-1}) = 1 + a_1 z^{-1} + a_2 z^{-2}$ $B(z^{-1}) = 1 + b_1 z^{-1} + b_2 z^{-1}$ (2)

The module for continuous identification had to be created again for Dahlin algorithm because the old module cannot identify the system with $b_2 = 0$. The standard method was used as in the old module (Bobal et al., 1999).

2.2 Regulator synthesis

The poleplacement method (Bobal et al., 1999) and method of inversion dynamic (Viteekova, 2000) were chosen for regulator synthesis. These two algorithms were taken from module library and converted by converter application. In addition new module for Dahlin regulator (Bobal et al., 1999) was created.

2.3 The mathematical library

The modules with control and identifying algorithms have to be calculated with real numbers. The mathematical library developed by Gordon Doughman was used (Dolinay, 2002).

This library was originally developed for M68HC11 family. Conversion had to be done to ensure compatibility with M68HC08 microcontrollers.

2.4 Hardware

The microcontroller M68HC908GP32 and the 908GP32 Starter Kit developed by Beta Control was used because of its relatively large memory space. This model contains 512 B of RAM. The memory requirements can be seen in Table 1.

The M68HC908GP32 has the minimal RAM space for the control process with continuous identification.

3. RESULTS

The examinations of the optimized modules were realized on the heat systems. The setpoint was set to 60 or 80[degrees]C. Sampling time was set to 2 seconds in all examinations.

The first peak in figures was caused by the fact that the controlled system had not been properly identified yet. This error can be removed in the next control process by better estimation of initial values of controlled system. The control process by inversion of dynamic is quite slow, but more precise then other two algorithms.

[FIGURE 2 OMITTED]

[FIGURE 3 OMITTED]

[FIGURE 4 OMITTED]

As can be seen in figures the largest overshoots are in Dahlin algorithm. On the other hand this algorithm has smallest memory requirements and is very fast for example in comparison with method of inversion dynamic.

4. CONCLUSIONS

The modules for quick programming are one of the possible way how ensure the simplicity of programming process. This work showed that old modules originally developed for M68HC11 might be transformed quite easily to the different microcontroller family.

This work is a part of the project that is focused on adaptive controlling of technological processes. Other modules for microcontroller from M68HC11 family can be developed and transformed in the same way as it was shown in this paper.

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6. REFERENCES

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Table 1 Memory requirements of control algorithms

Name of the method	Memory requirements (without stack)
Method of inversion dynamic	374 Bytes
Poleplacement method	445 Bytes
Dahlin algorithm	267 Bytes

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