Proceedings of the 5th WSEAS Int. Conf. on Signal Processing, Robotics and Automation, Madrid, Spain, February 15-17, 2006 (pp131-134)

Temperature Control Using Autotuning PID Controller for Control Education

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Abstract: - The focus of this paper is Graphical User Interface (GUI) based control of the temperature using autotuning PID Controller, which is efficient in advance student learning. The aim of computer based education is to develop the learning capacity of students and increase the teaching efficiency with computer based technology. A MatLab-based GUI program has been implemented to the oven for the temperature control. Data communication link is established between a digital signal processing card and a computer, where the computer hosts a GUI for the digital signal processing card. For the system two kinds of software is applied. One of them is microcontroller software and the other is computer software. This software is corresponded by RS-232 protocol. This experimental system can give an efficient way for students to understand the main of process dynamics and prepares students for the challenges of the professional world where the computer has a significant place.

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Key-Words: - Temperature control, GUI, Education, Autotuning PID controller

1 Introduction

The use of computer in education is becoming a more popular. Computer based education is a computer based methods and tools which is used to increase learning performance [1]. Computer based education offers many advantages. For example the ability to run simulations of laboratory experiments that allow the student to see the effect by modifying various parameters. So by means of practice, students will motivate, promote critical thinking, facilitate understanding in the use and limitations of the theory [2] Practice in education can greatly help the learning process. Students are able to learn by themselves, student advancement and areas of difficulty can be automatically monitored [3]. Computers can be used in numerous ways for education. They can be used as a graphic module in lectures, as a computation tool, as an electronic textbook, as a research tool [4]. Using some software can provide to create computer graphics that display data for interpretation [5]. MatLab has all of the graphing features and it's a powerful software package that allows for plotting data [6,14]. It is widely used in academia and industry because of its advanced capabilities and a simple user interface. Several studies have described MatLab GUI as a platform for academic research and education. GUI is being increasingly used in education to provide users of computer simulations with image approach and increased configuration flexibility [7]. Thus the simulation and experimental study can be done easier. In education, the classical methods have been to explain as an experimental study using computer. So the student can then easily indulge in "what if' studies to find an optimal structure and set of control parameters for the controllers the fundamental aim of process control [8]. Thus students can see the effects of the parameters by the simulation and implementation. On the other hand, in the application of process control to real processes provides hands-on training for students. Fundamentals of process control need to be taught in a more practical and tangible way which is an academic requirement. Many sophisticated control strategies, such as model predictive control, are also organized hierarchically based on PID control [9]. PID controllers are standard tools for the industrial applications, because they are simple and robust. But it is difficult to define the PID controller parameters properly. So practicability of the controller is reduced and loss of time occurs. Most of the classical industrial controllers have been provided with special procedures to automate the adjustment of their parameters (tuning and self-tuning) [10,11] and autotuning methods are developed.

Data communication link is established between a digital signal processing card and a computer, where the computer hosts a GUI for the digital signal processing card. For the system, two kinds of software are applied. One of them is microcontroller software and the other is computer software. This software is corresponded by RS-232 protocol. This communication is implemented full-duplex. This experimental system can give an efficient way for students to understand the main of process dynamics.

2 Experimental structure of the oven

This study shows implementation of computer based education with MatLab based GUI using autotuning PID controller. Digital signal processing card is designed and an oven is constituted for temperature control.. In education, the classical methods have been to explain as an experimental study. So the student can then easily indulge in "what if" studies to find an optimal control structure and set of control parameters for the controllers [8]. The oven of temperature information is read by temperature sensor and produces the voltage about 0-50 mV. This voltage is supply the necessary PWM value around 0% and 100% by means of the digital signal processing card. In power control card PWM signal is constituted which is coming from network and the system is controlled according to the PWM. Fig. 1 shows the block diagram of the temperature control system.

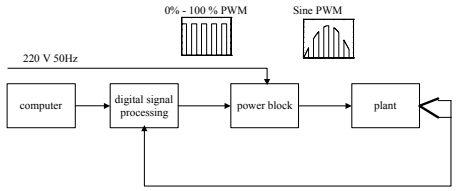

Fig. 1 The block diagram of the temperature control system

2.1 Features of Digital Signal Processing Card-PIC17C44 Microcontroller - ADS1212 A/D converter and Power Unit

For computer based education, the experimental set is implemented using digital signal processing card, PIC17C44 microcontroller, ADS1212 A/D converter and power unit. In this section, these units will be explained briefly. Digital signal processing card provides knowledge transition among the computer, system and power unit. Temperature data which is come from system is translated digital signal form using ADS1212 A/D converter. This data is sent to the computer. On the other hand control knowledge which is come from computer is sent to the power unit. All the process is implemented by PIC17C44 microcontroller. Microcontroller is corresponded with A/D converter using SPI (Serial Peripheral Interface) mode. PIC17C44 Microcontroller has 33 port as input / output, 2 PWM output, 58 instructions, interrupt ability, 64 Kx16 program memory which could be addressed, direct / indirect / relative address mode, CMOS Eprom technology which has low power and high rate. PWM resolution is between 1 and 10. ADS1212 A/D converter has low power consumption, differential inputs, programming gain amplifier, programming interrupt frequency about 6,25 KHz. Energy (sinus PWM) which is given the system, is controlled by power unit. PWM modulation technique is used because of simple design, rapid energy control (high frequency PWM). Power unit consist of IGBT and IGBT driver. IGBT driver makes the PWM signal which is 18 KHz and 10 bit, suitable form for IGBT. Fig. 2 shows the experimental temperature control system using MatLab based GUI.

Fig. 2 the experimental temperature control system using MatLab based GUI.

3 Graphical User Interface based autotuning PID Controller of the Oven

The focus of this study is GUI based control of the temperature using autotuning PID Controller which have been to be efficient in promoting student learning. GUI is being increasingly used in education to provide users of computer simulations with image approach and increased configuration flexibility [7]. Serial communication is a low-level protocol used for data communication between two or more devices. As the name implies, serial communication uses a data port to send/receive data in a serial manner [6]. In this paper, a data communication link is established between a digital signal processing card and a computer, where the computer hosts a GUI for the Digital signal processing card. RS-232 serial communication is used. Fig. 3 shows representation of serial cable.

Table 1 presents digital signal processing card is shown connected to a computer through a RS-232 serial cable. Fig. 4 shows digital signal processing card and RS 232 serial cable for the experimental set.

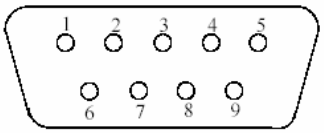

Fig. 3 Representation of serial cable

Table 1 Digital Signal processing card is shown connected to a PC through a RS-232 serial cable

Pin #	Label	Signal Name	Signal Type
1	CD	Carrier detect	Control
2	RD	Received data	Data
3	TD	Transmitted data	Data
4	DTR	Data terminal ready	Control
5	GND	Signal ground	Ground
6	DSR	Data set ready	Control
7	RTS	Request to send	Control
8	CTS	Clear to send	Control
9	RI	Ring indicator	Control

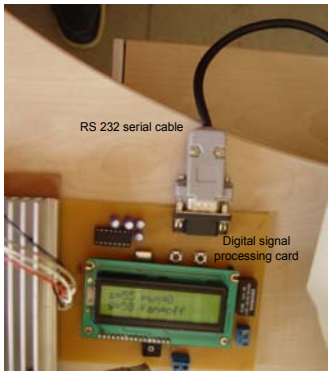

Fig. 4 Digital signal processing card and RS 232 serial cable

Using some software can provide to create computer graphics that display data for interpretation [5]. MatLab has all of the graphing features needed and it is a powerful software package [6]. It is widely used in academia and industry because of its advanced capabilities and a simple user interface. Several studies have described MatLab GUI as a platform for academic research and education. This experimental system can give an efficient way for students to understand and test the main of process dynamics. Using this experimental structure, students can change desired temperature value of the oven and they can see current temperature value of the oven by using MatLab based GUI. Experiments bring practical experience to students. These kinds of experimental education facilitate students the practical verification of their ideas and teach them to work [12].
Fig. **5** presents the GUI based window that shows the temperature of the oven simultaneously and by means of the window you can input the desired temperature value and the experimental set attain to the desired temperature value.

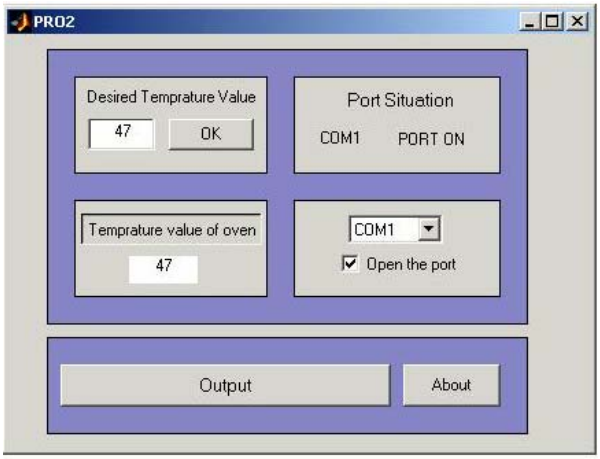

Fig. 5 GUI based window for temperature control

4 Perspective of Computer Based Education

The use of computers is recently common in education. In the form of computer-based education or in the use of common software tools in uphold of students' research, writing and presentation activities [13]. Computers can be used in numerous ways for education. They can be used as an graphic module in lectures, as a computation tool, as an electronic textbook, as a research tool. Using some software can provide to create computer graphics that display data for interpretation. So in the scientific areas and altered education concepts and many universities determined to plan new strategies concerning computer based technologies. The aim of Computer based education is to develop the learning capacity of students and increase the teaching efficiency with advanced computer based technology [5]. Using computer can greatly help the learning process in practice. Thus students will be motivate, promote critical thinking, facilitate understanding in the use and limitations of the theory. The experimental study with computer prepares students for the challenges of the professional world that the computer has a significant place in the industry.

5 Conclusion

This paper presents the experimental set which is implemented using digital signal processing card, PIC17C44 microcontroller, ADS1212 A/D converter, power unit and MatLab based GUI for computer aided education. The focus of this study is GUI based control of the temperature using autotuning PID Controller which have been to be efficient in promoting student learning. For the system two kinds of software is applied. One of them is microcontroller software and the

other is computer software Using this experimental structure, students can change desired temperature value of the oven and they can see instantaneous temperature value of the oven by using MatLab based graphical user interface. Experiments bring practical experience to students and give an efficient way for students to understand the main of process dynamics.

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