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LOW COST APPLICATION FOR ALGORITHM CONTROL STUDY

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ABSTRACT

The paper proposes a low cost educational application for PC, connected to the parallel port in order to study different control algorithms. It is possible to implement both simple control algorithms as on-off, PID, etc. and complex algorithms as adaptive-predictive or fuzzy. It is presented a practical example for a thermal process which uses an adaptive-predictive algorithm. The algorithm uses on-line simulation and rule-based control.

KEYWORDS: Serial ADC, PID, adaptive-predictive control, least squares method.

1. INTRODUCTION

The study of control algorithms (simulations and experiments), requires important hardware and software resources. To study different control and identification algorithms, this paper proposes a low cost educational application for PC, connected to the parallel port. The practical experiments permit to validate or invalidate a control algorithm, and can lead to a reappraisal of some theoretical aspects, than the simulations must be resumed. But on the other hand, the simulation permits a simple modifying of process parameters; in practical experiments, only some parameters and conditions can be easily modified. Another problem is the duration of the experiment. So, it is a good choice for applications to permit both simulations and practical experiments.

2. THE PROPOSED APPLICATION

For the experiments on control algorithms is proposed the application with the schematics that can be seen in figure 1. This includes a minimal hardware in order to measure the temperature using an 8 bit resolution serial analog to digital converter, TLC549. For temperature sensor it is used a precision centigrade temperature sensor, LM35, with 10mV/°C sensibility. As heat supply is used a power resistor connected to a variable power supply (0-30V/3A) that can adjust the maximal power delivered to the system till 90W. The power supply can be switched on/off with an 8 bit PWM type control. In a sample period interval T, the heat supply is active a time T1 and inactive a time T-T1. The control algorithm will generate the value of T1; using this method, in many cases it is possibly to consider that the control signal is (pseudo) continue. The heat supply and the sensor are connected on the same radiator in a closed box. The application is a stand-alone assembly that is connected on a PC parallel port[6].

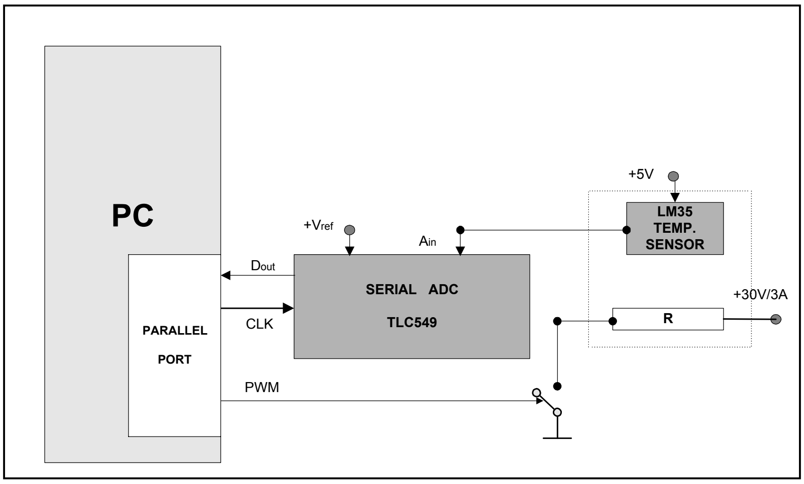

Figure 1: The schematics of the application

3. ADAPTIVE- PREDICTIVE CONTROL EXPERIMENT

Let's consider a linear model of the process:

where: $$A\left(q^{-1}\right)y(t) = q^{-d}B\left(q^{-1}\right)u(t) \tag{1}$$

$$A(q^{-1})=1+a_1q^{-1} + ... + a_nq^{-n} \tag{2}$$

$$B(q^{-1})= b_1q^{-1} + ... + b_mq^{-m} \tag{3}$$

$$q^{-1}y(t)=y(t-1) \tag{4}$$

d - denotes dead time (5)

$$u_{min} \le u(t) \le u_{max} \quad \text{(the limits of command)} \tag{6}$$

In this experiment it is used an adaptive-predictive algorithm which uses on-line simulation and rule based control [4], [5]. The conditions of experiment are hard: the system is not thermic isolated and there is not used a ventilator.

The algorithm is implemented in "C" language (the reason is that it is possibly to use a cheap PC) or in DELPHI. It was used a model with n=3, m=2, d=1 in (1)...(4), so the system has three poles and two zeros. For parameter identification there is used the least squares method. The control signal (the electric current through resistor), can be between **0….2A**. In figure 3, the control signal was represented in DAC (digital analog converter) units (0..250).

The analog digital converter has only 8 bits. To increase the resolution, it is used multiple measurements to eliminate the extremes and is made the average of samples. These operations lead to a better behaviour of identification algorithm especially in transitory regime. It is preferable to make the measures in the last quarter of sample period. Usually, it is suggested to choose a small sample period, but in noise conditions, a small sample period can affect the quality of identification algorithm. Here, the sample period respects next condition: if the command is u_{max} or u_{min} (for a long time), the output variance must be significantly comparatively with the noise. In this example, sample period was chosen at 15 s.

Initially, the temperature of process is 25**°C** and setpoint is changed to 75**°C**. The parameters of model at start are: A[.]=0; B[.]=0.

- For 1…31 steps, the algorithm builds $u(t)=u_{max}$ and the identification process is started.
- As a result, at step 28, the algorithm builds $u(t)<u_{max}$ and the signal control is $u_{min}<u(t)<u_{max}$
- At step 32 the setpoint is reached and then the override is less than 1°C.

- For steps 32….68 the variance of control signal decreases; for this, the difference $u_{maxst}(t)$-$u_{minst}(t)$ decreases and it is applied an average to control signal.
- At step 68 the setpoint is changed to 50°**C**; as a result the algorithm builds u(t)=0.
- At step 82 the algorithm begins to build u(t)>0 and than the setpoint is reached at step 90, without considerable override.
- At step 112 the setpoint is changed to 75°**C**. As a result, the algorithm builds $u(t)=u_{max}$.
- After step 129 the algorithm builds $u_{min}<u(t)<u_{max}$ and so on. Of course it is a real process, so if there are differences between process and model, the control system do not work very well (for steps 135.140 the error is 1.25°**C**…1.5°**C**).

In figure 2 is represented the output (temperature) and setpoint. In figure 3 it can be seen the control signal u(t) and the limits of control signal $u_{maxst}(t)$ and $u_{minst}(t)$. In this experiment, because it is used an on/off actuator, and because it is used electrical heat, *the variance of control signal is not penalized.*

In figure 4 are represented the parameters A[.] (for B[.] vector it is used a similar window). Initial A[.]=0 and than RLS algorithm identifies these parameters.

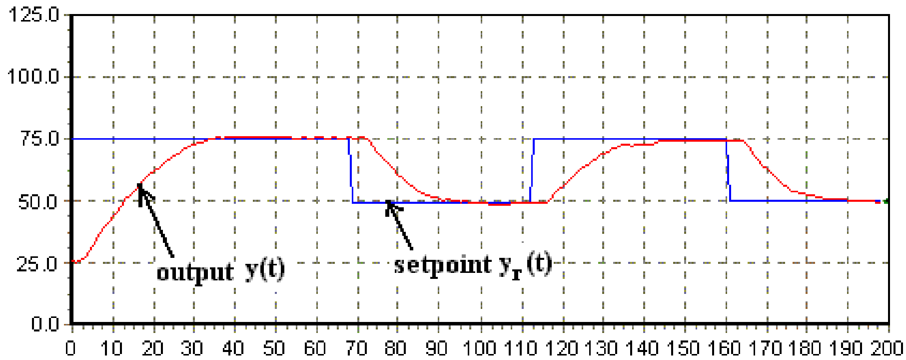

Figure 2: Setpoint $y_r(t)$ and output $y(t)$

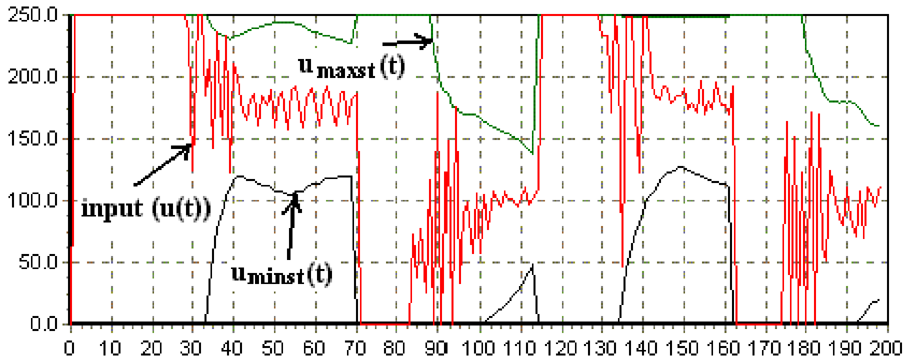

Figure 3: Input $u(t)$, $u_{maxst}(t)$ and $u_{minst}(t)$

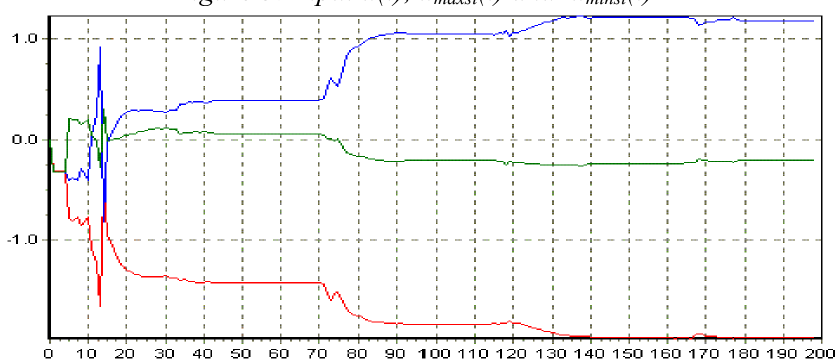

Figure 4: Identification- of model parameters A[.]

For this experiment, the poles/zeros distribution after 200 steps is represented in fig. 5 (poles-triangle; zeros-circle). Also a hint indicates the values of poles and zeros.

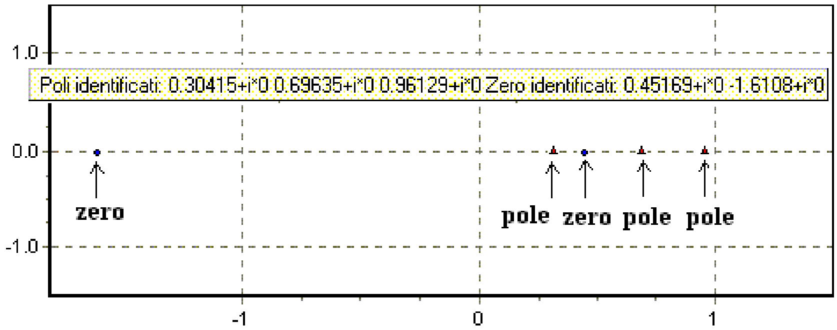

Figure 5: Poles/zeros distribution

4. CONCLUSIONS

The application requires few resources and is more accessible than other complex and expensive solutions (like Labview) and can be easy implemented.

The software can be modularly developed to simplify the different control algorithm implementation. Using the proposed system with the mentioned parameters it can be experimented thermal processes and control the temperature from ambient to 95°**C** when the sensor allow to measure the temperature till 150°**C**.

Using a C or DELPHI software application that command via the parallel port the assembly, the process (inputs, outputs, poles, zeros, predictions, errors, model parameters etc.) can be easily represented on display; setpoint and some parameters of identification and control algorithm can be modified in real time. In addition, because the PID control is implemented too, it is possibly to compare adaptive predictive algorithm, PID algorithm or other type of control algorithms.

Some improvements for the assembly are also possible: the use of a 10 bits serial ADC, a ventilator to uniform the temperature and a Pelttier device that increases the possibilities of control.

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