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ANALOG MODUL APPLICATION IN THE PLC DESIGNS THE CONTROLLER FOR A HEATING SYSTEM

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ABSTRACT
To serve the training, with logic control problems, our automation laboratory used PLC programmable logic controller and built practical exercises for the subject of control logic controller and PLC. However, with the analog control problem, there are currently no practical exercises to verify the control algorithm... So, the article proposes a solution to research and build a controller using the analog module of the controller PLC to control the heating object, the results of this study are used as practice and experimental documents for the subject of PLC coupled control.

Keywords:
Heating system, PLC, using the analog module of PLC to control the heating object

INTRODUCTION
In life as well as in production, the requirements for the use of heat are very large. This heat source is received by electrical devices that convert from electricity. This is a clean energy source, does not cause smoke and dust, so it does not affect the living environment, convenient and easy to use.
Heating methods: induction heating, arc wire heating, resistance wire heating. In this paper, the author focuses on analyzing the heating device by resistance wire.
Resistance heating method is based on Joule -Lence's law: when a current flows through a wire, a heat is released in the conductor, this heat is calculated according to the expression (2.1)

$$Q = I^2 Rt \qquad (2.1)$$

With:

Q – Heat (J)
I – Amperage (A)
R – Resistance (Ω)
t – Time (s)

Some types of sensors measure temperature in practice such as: mercury thermometer, thermistor, thermocouple.

THE BUILDING A MATHEMATICAL MODEL OF THE RESISTANCE FURNACE BY EXPERIMENTAL METHOD
To design a controller for the object needs to build a descriptive mathematical model for the object. The author uses zaded 's object recognition method.

In order to estimate the model of the object, we provide an AC voltage source to the resistance coil. Then, we measure the temperature response of the system. Voltage and thermal signals are achieved by Arduino UNO and then sent to MATLAB/Simulink. We perform data collection of voltage and temperature over time with a sampling period of 200ms. After that, we find the mathematical model of heating object (called tranfer funtion describing approximately real object) by using Identification Toolbox in MATLAB.

This process includes several steps and finally, we have a set of data as shown in Figure 2.1 and Figure 2.2.

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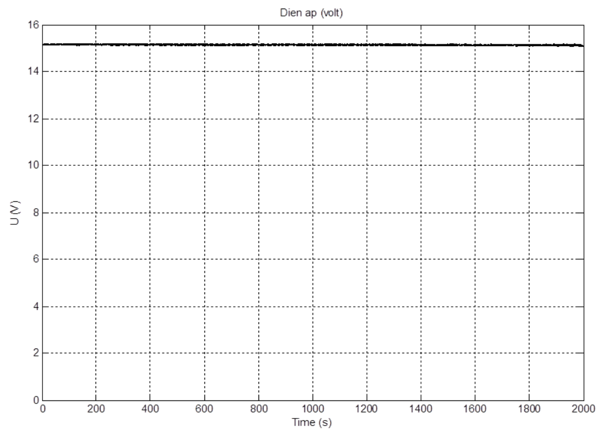

Figure 2.1: Voltage data (Volt)

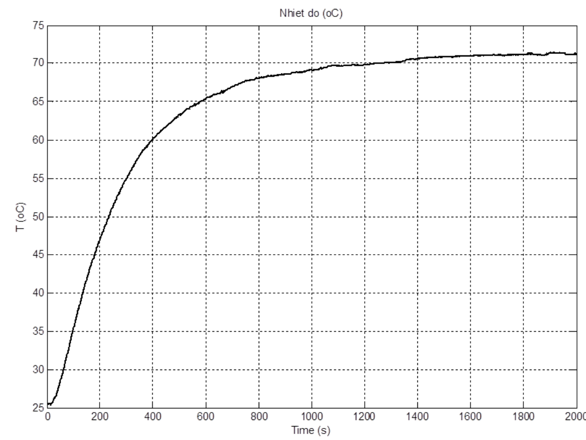

Figure 2.2: Temperature data (^oC)

The mathematical model of resistance wire is written as in equation

$$W(s) = \frac{T(s)}{U(s)} = \frac{K}{1+\tau s} \qquad (2.2)$$

Where:

$K = 4,689; \tau = 272,51$

We get the transfer function of the system after replacing the number:

$$W(s) = \frac{T(s)}{U(s)} = \frac{4,689}{1+272,51s} \qquad (2.3)$$

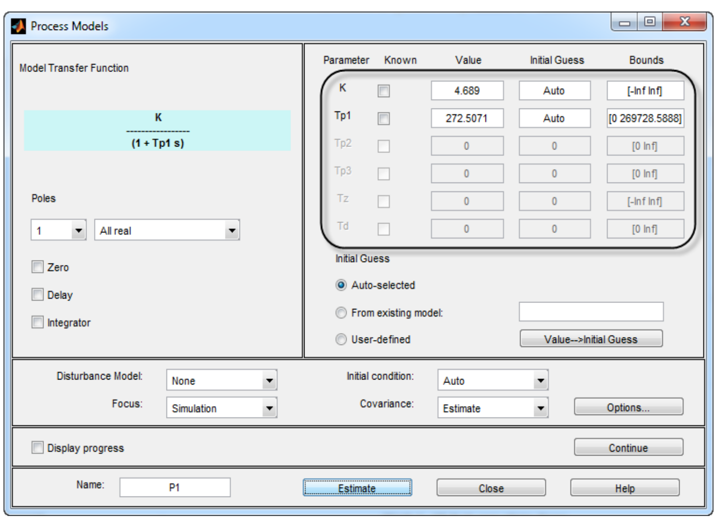

Figure 2.3: The object model after identification

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We continue to conduct to estimate models, and receive a result with the fit level between the identificated model and data reachs 95.23%.

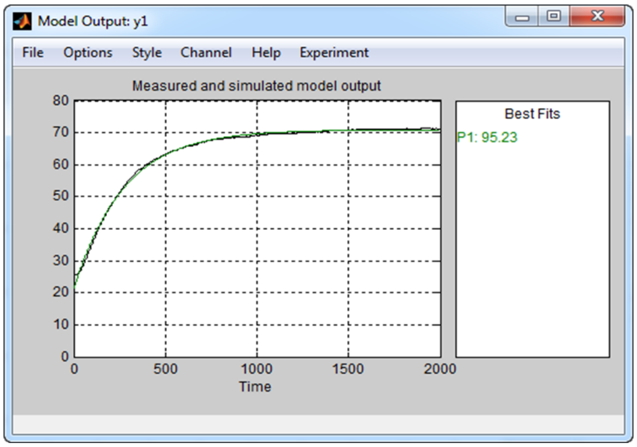

Figure 2.4: The best fit between model and data

Additionally, the temperature of the resistance wire is varied by altering the voltage of an AC-AC converter from 36V to 10V. Its transfer funtion is shown in:

$$W_b(s) = \frac{U(s)}{u_{dk}(s)} = \frac{K_b}{1+\tau_b s} = \frac{3,6}{1+0,005s} \qquad (2.4)$$

The controlled object includes the converter and the resistance coil connected in series. we have the transfer funtion of heating object:

$$G(s) = W(s).W_b(s)$$

$$G(s) = \frac{16,8804}{(1+272,51s).(1+0,005s)} \qquad (2.5)$$

DESIGNING CONTROLLER PLC USING ANALOG MODUL TO IMPROVE QUALITY CONTROLLING FOR A HEATING SYSTEM

This paper applies a PIDcontroller to the proposed heating system. This research aims at controlling and keeping the degree of heat stable.

$$G_{dk}(s) = K_P(1+\frac{1}{T_i s}+T_D s) \qquad (3.1)$$

Determining parameters of the controller (K_P, T_i, T_D) will have direct effect on the quality of system. This process is implemented by an optimal module.

$$|W_k(j\omega)| = 1 \qquad (3.2)$$

Applied to the heating control system, with $\tau = 0,005(s)$

$$G_{dk}(s) = \frac{1}{G(s).2\tau s(1+\tau s)} \qquad (3.3)$$

The transfer function of the controller is written as follows:

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$$G_{dk}(s) = \frac{1+272,51s}{16,8804.2.0,005s}$$

$$G_{dk}(s) = 1614,3575(1+\frac{1}{272,51s}) \qquad (3.4)$$

The article mentions the use of analog module in PLC S7-200 to implement the above synthesized PID control law.

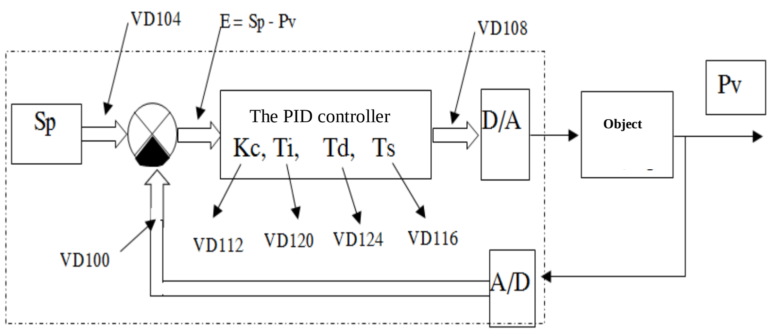

Figure 3.1: The structure of PID controller on PLC S7-200

Experimental devices is used in the model:

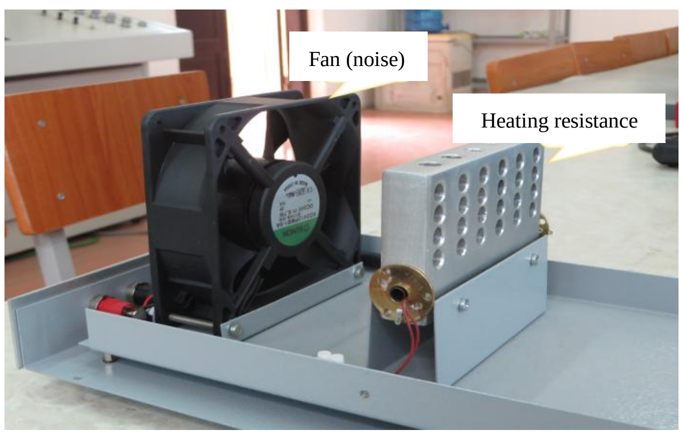

Figure 3.2: The heating resistance and fan

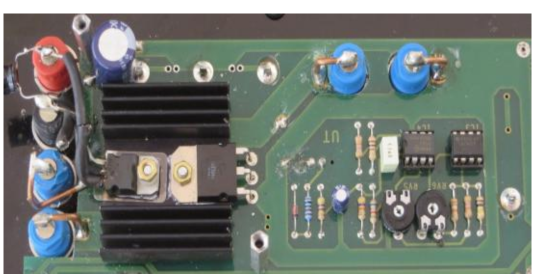

Figure 3.3: The temperature signal amplifier board and converter

Figure 3.4: The temperature signal amplifier board and converter

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The experimental module uses PLC S7-200 CPU224 and 01 module EM 235.The author uses the PID controller programming tool for the S7-200 on the Step 7 MicroWin programming software to install the control law for the heating device.

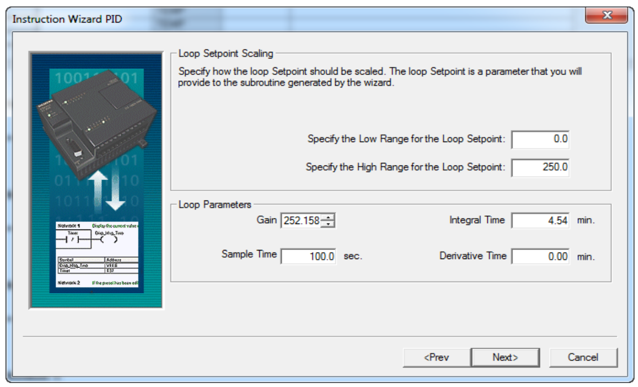

Figure 3.5: The PLC S7-300 configuration

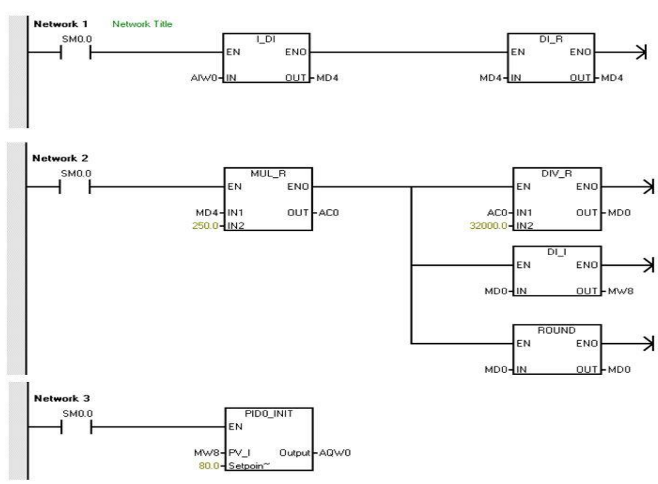

Figure 3.6: The control program on PLC S7-300

When conducting experiments with control signals from 0-10V, the control quality is not satisfactory. The quality of this response is worse than that of the simulation system. It can be expained that the difference between the identified system and the real system. Therefore, the parameters of the controller could be re-estimated with: K_P =1612,6275 and T_i = 268,025. The controller with parameters as expression (3.5).

$$G_{dk}(s) = 1612,6275(1+\frac{1}{268,025s}) \qquad (3.5)$$

The reaction of the system with a step function T_{ref} = 120^{o}C is as figure 3.7

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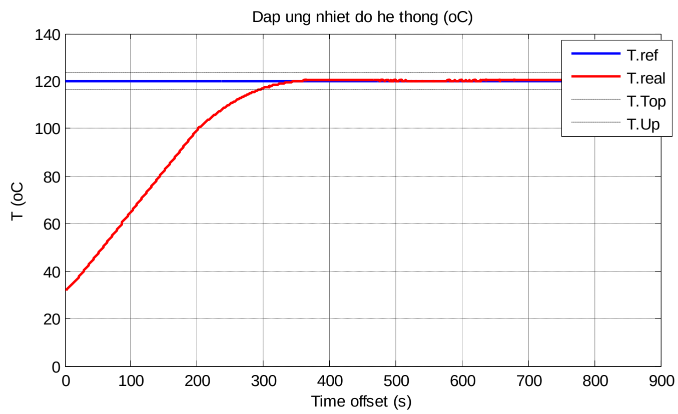

Figure 3.7: The system temperature with step temperature signal

In the Figure 3.7, it seems that the system reaction has no overshoot, and settling time is 290s.
When input function varies, output signal follows it and it takes about 278s for settling time. It is showned in Figure 3.8.

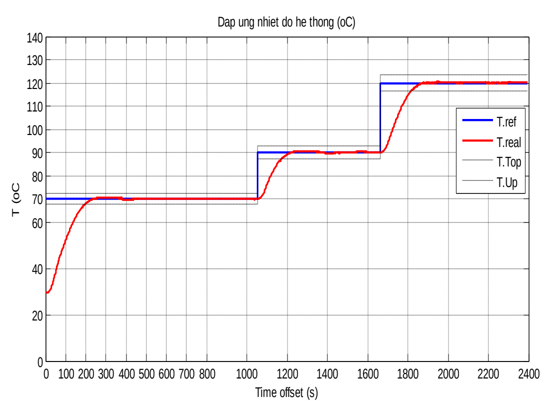

Figure 3.8: The reaction of the system with variable input

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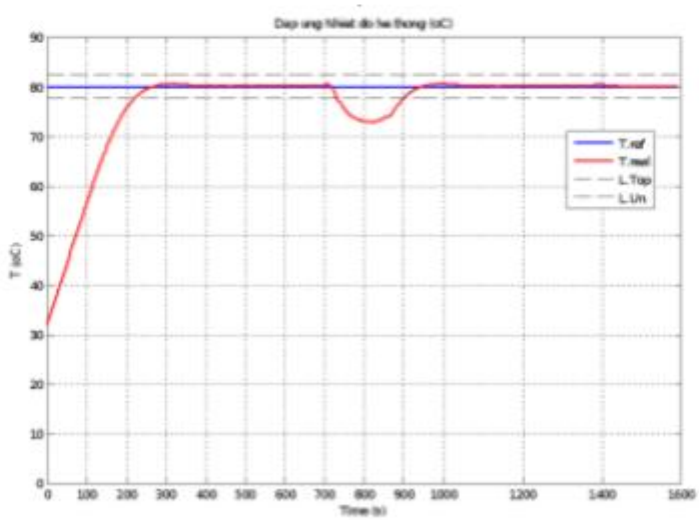

Figure 3.9: The response when exitting disturbance

We set temperature $T_{ref} = 80^oC$, and then put disturbance into the system at 700s. Nearly 200s after the existence of the disturbance (the cooling fan) impacts on system, the difference between input and output is nullified to meet the control requirements.

CONCLUSION

In this paper, a thermal system is proposed. The PID controller is used to drive supply voltage for the resistance coil to alternate temperature in order to follow technical demands. Finally, it should be re-emphasized that the heating system proposed in this paper can achieve a good performances and effectiveness. In the future, this system will provide a series of practical experiments for the subject of PLC taught at TNUT.

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