SOLDERING STATION

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SUMMARY

Nowadays, there are many kinds of soldering irons such as: pulse soldering iron, baking soldering iron, but these machines are not stable in temperature and are not highly accurate during working time. Besides those, they cannot be controlled in temperature for different applications. To overcome the disadvantages of the old kinds of soldering irons, the soldering station, which can change the temperature and track and stabilize around the setting points, has been discovered in this paper. The authors will build the mathematic model of the system, design the controller, and simulate using Matlab Simulink. Specially, producing and experimenting on the real solder station to illustrate the theory are the last part of this paper.

Key words: *Soldering station, mathematic model, setting point, temperature*

INTRODUCTION

Understanding of technical requirements and determining the main parts of the relatively plant model are the very important works in controlling plant and designing a real high effective device. Along with standards, evaluating the quality of the system such as keeping stable output, reaching set point quickly is very difficult if there have no good and accurate mathematical model of the plant and suitable controller. Calculation in theory helps us build up the exact form of controller, and then applies that in reality which is very important and effective for designing and controlling a real device. Many factors make difficult to get the small error, and fast time responding such as: the nonlinear, high delay time plant and approximation to find the transfer function for the nonlinear parts. Moreover, when creating the real device, changing among units, measuring, and communication transforming make the real product more difficult to control. In this project, the author will study and investigate specifically the structure of soldering station from that determine mathematical model in part II, calculating and designing suitable controller then simulating by Matlab Simulink in part III, manufacturing Soldering station and testing in part IV. The last part is the conclusion in V.

THE MATHEMATIC MODEL OF SOLDER STATION

Here is a simple circuit that provides manual control of the temperature of an ordinary 24V AC soldering station.

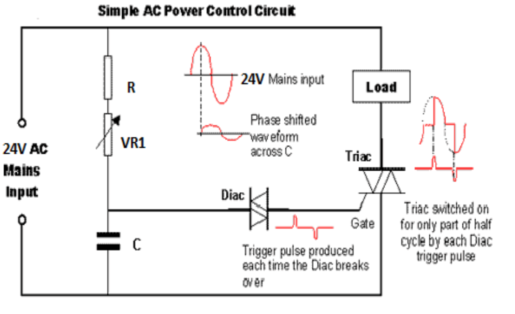

Figure 1: *Working principle diagram of solder station*

Assuming the Load in picture is the soldering iron, so operation of the circuit is adjusted the output voltage signal of TRIAC by changing the value of VR_1. The working principle of this circuit is can be explained as during the positive half cycle the capacitor C_1 charging, when the capacitor charges up to V_c, then the DIAC starts conduction, when the DIAC turn ON, it gives a pulse to the gate of TRIAC due to which TRIAC start conduction and current flow through the Load. During the negative half cycle, the capacitor charges in reverse. The output of the DIAC is given to the gate of

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the TRIAC; this output use to trigger the gate of the TRIAC, so the TRIAC start conduction and the lamp will be energized. So by changing VR_1, the Load will receive different values of voltage that is equivalent to the change of temperature of the soldering iron.

Solder iron

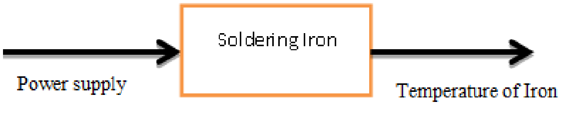

Figure 2: *The relation between Input and Output*

The Input is Power Supply and the Output is temperature

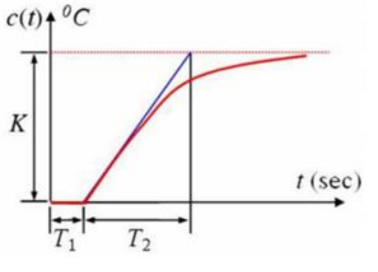

Figure 3: *The characteristic of Soldering Iron*

The Transfer Function of Soldering Iron

$$W_{SI}(s) = \frac{e^{-Ls}}{T*s+1}$$

Q: Thermal energy (Jun); I: Current (A); R: Resistor – Iron (Ω); T: Time (s)

Temperature sensor

A temperature sensor is a device, typically, a thermocouple or RTD that provides for temperature measurement through an electrical signal. A thermocouple (T/C) is made from two dissimilar metals that generate electrical voltage in direct proportion to changes in temperature. An RTD (Resistance Temperature Detector) is a variable resistor that will change its electrical resistance in direct proportion to changes in temperature in a precise, repeatable and nearly linear manner.

The general transfer function of Temperature Sensor is:

$$G(s) = A*\frac{T_c}{T*s+1}$$

Where A, Tc, T are sensor coefficients

Triac circuit

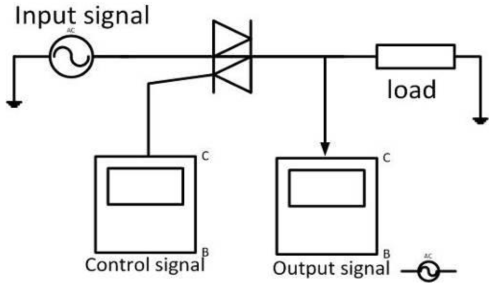

Figure 4: *Triac circuit*

The transfer function is:

$$W_{dk}(p) = K_{dk}e^{-T_{dk}s} \approx \frac{K_{dk}}{1+T_{dk}s} \quad \text{for } T_{dk} \approx 0$$

From parts a, b, and c we can have closed loop system for the plant need to be controlled follow:

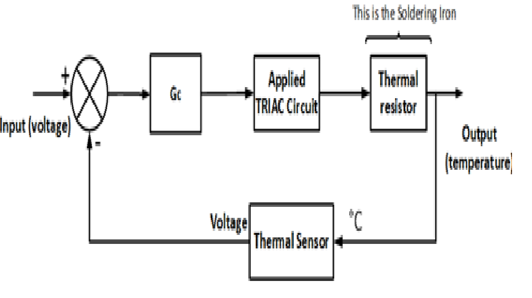

Figure 5: *The closed loop system of Solder Station*

This diagram shows the relationship of all parts of Solder Station, the input is voltage and the output of system is temperature.

SIMULATIONS

Based on what we did in part II, we can redraw by replacing transfer functions of each block.

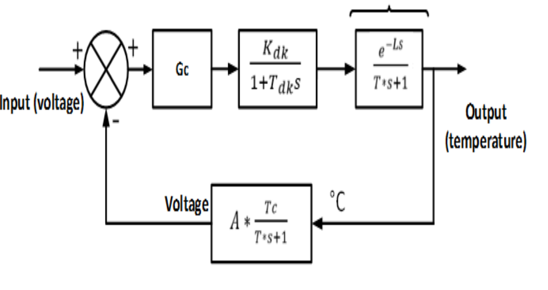

Figure 6: *The relationship of the input and output through transfer function*

Applying system theory we have following close loop system:

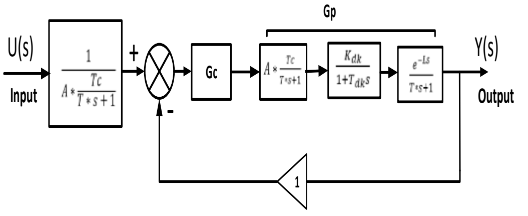

Figure 7: *System in Matlab Simulink*

It is observed that when the proportional gain alone is chosen arbitrarily, the response of the solder station is not satisfactory. The same problem is experienced when the integral gain and the derivative gain alone are concentrated on. Therefore, in order to have the desired response, the PID controller has to be tuned. Tuning of PID controller using a trial and error method wastes time and if not properly tuned the solder station could be damaged. To save us a lot of efforts, a tuning guide proposed by Ziegler-Nichols is adopted with the aim of; shortening the rise time, eliminate/reduce the overshoot, quickening the settling time of the system to a steady state, and reducing to a tolerable value the steady-state error which is the difference between the steady-state output and the desired output [3]. When the PID controller is properly tuned according to Ziegler-Nichols tuning rule applied to a unit step input system, and with proportional gain, Kp = 132, integral gain = 12, and derivative gain = 8, the following response or plot is obtained:

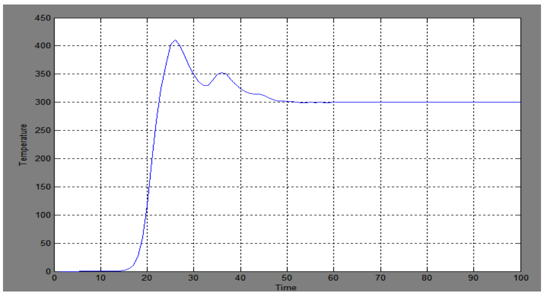

Figure 8: *The characteristic of the system*

EXPERIMENTAL RESULTS

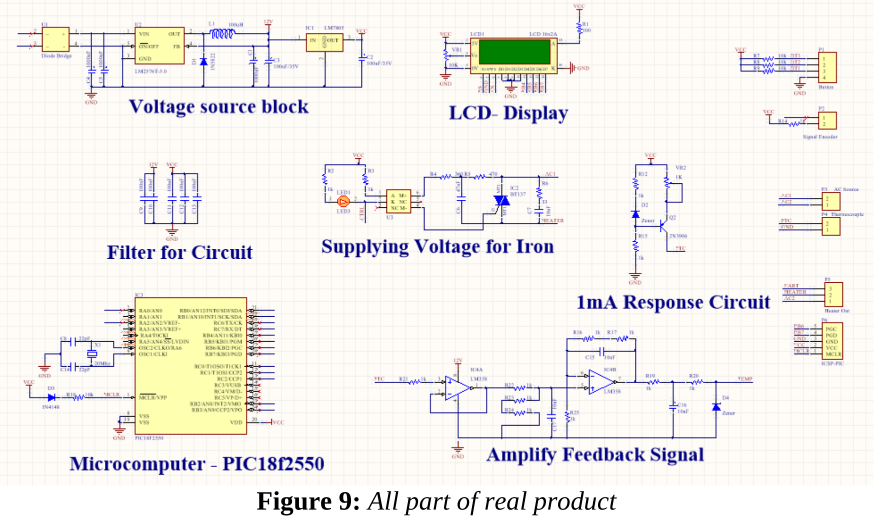

Figure 9: *All part of real product*

Functions of each part: Voltage source block creates +24V value to supply for soldering station. LCD displays the temperature of soldering station. Supplying Voltage for Iron is +5V value supplying for iron; Response circuit (1mA) is the circuit to create 1mA current through iron. Micro-controller PIC18F2550 and Amplify feedback signal.

Real product

Here is the real Solder Station, we can change the set points and the system can keep the temperature around those points.

There are 3 buttons in real product for controlling the temperature of soldering iron. Red button: to RUN or STOP working of machine. Green button with minus sign: to DECREASE the temperature. Green button with plus sign: to INCREASE the temperature. *C = degree Celsius (℃)

CONCLUSIONS

In this paper, the authors built the solder Station from theory to real product. All critical parts of the system are presented in mathematical model. From that, the controller is design correctly to keep the output constant around the set points. Real product once again demonstrates the theory correctly. Especially, Solder station overcomes the disadvantages of other products having same purposes in reality.

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TÓM TẮT

MÁY HÀN TỰ ĐỘNG ỔN ĐỊNH NHIỆT ĐỘ

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Ngày nay, có rất nhiều các loại máy hàn như: máy hàn xung, máy hàn nóng, nhưng các máy này không tự động ổn định nhiệt độ và không chính xác trong thời gian làm việc. Bên cạnh đó, chúng không thể kiểm soát nhiệt độ cho các ứng dụng khác nhau. Để khắc phục nhược điểm của các máy hàn này, máy hàn tự động ổn định nhiệt độ, có thể thay đổi được nhiệt độ và bám và ổn định xung quanh các điểm thiết lập, được đề cập trong bài báo này. Các tác giả sẽ xây dựng mô hình toán học của hệ thống, thiết kế các bộ điều khiển và mô phỏng sử dụng Matlab Simulink. Đặc biệt, sản xuất và thử nghiệm trên máy hàn thực để minh họa cho lý thuyết được đề cập trong phần cuối cùng của bài báo này.

Từ khóa: *Máy hàn ổn định nhiệt độ, mô hình toán học, điểm đặt, nhiệt độ*

Ngày nhận bài:20/6/2015; Ngày phản biện:06/7/2015; Ngày duyệt đăng: 30/7/2015
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