Reliable Self Tuning Fuzzy Logic Controller for Water Bath System

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ABSTRACT
This project is based on the self-tuning fuzzy logic controller, for the design of a temperature control process , the performance of the system should be reliable. The proposed control system combines the advantages of Self Tuning and Fuzzy Logic Control schemes. In order to evaluate the performance of the proposed control system methods, results from simulation of the process are presented. The hardware implementation using lab VIEW also present here. The entire system setup especially driver circuit is very critical for proper working of the system.

Keywords
LabVIEW, Fuzzy logic controller, Self-tuning, System identification, Water Bath system

1. INTRODUCTION
Fuzzy logic control systems, which have the capability of transforming linguistic information and expert knowledge into control signals are currently being used in a wide variety of engineering applications. The simplicity of designing these fuzzy logic systems has been the main advantage of their successful implementation over traditional approaches such as optimal and adaptive control techniques Despite the advantages of the conventional Fuzzy Logic Controller (FLC) over traditional approaches, there remain a number of drawbacks in the design stages. Even though rules can be developed for many control applications, they need to be set up through expert observation of the process. The complexity in developing these rules increases with the complexity of the process. FLC's also consist of a number of parameters that are needed to be selected and configured in prior, such as selection of scaling factors, configuration of the center and width of the membership functions, and selection of the appropriate fuzzy control rules.

2. SYSTEM DESCRIPTION

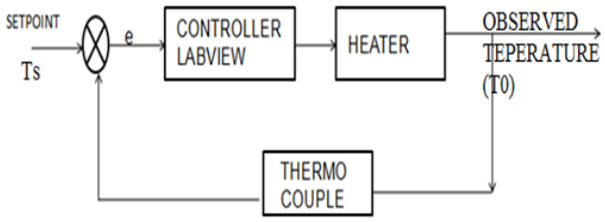

Fig.1 Block diagram of the system

The entire systems consist of Self-tuning fuzzy logic controller heater and thermocouple. The controller is implemented in lab VIEW .The thermocouple is used to measure the temperature inside water tank .The difference between observed temperature and set point is considered as the error.

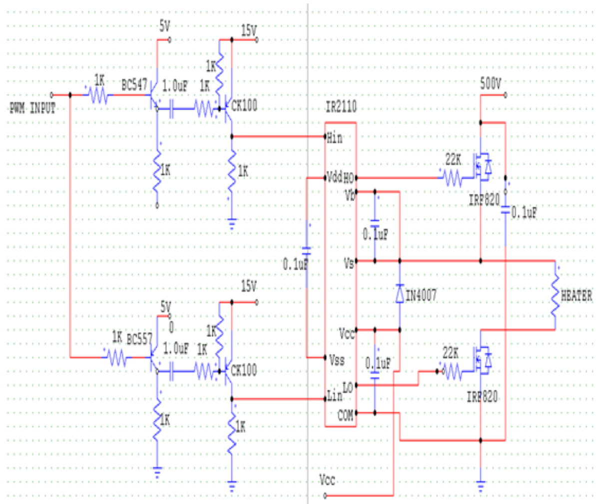

Fig. 2 The Psim diagram of driver circuit

It consist of mainly IR2110 , BC547,BC557and CK100, PWM input can't directly connected to the driver IC IR2110.The driver IC have two input and output. We should apply the high and low input in the same instant, for this purpose only transistors are arranged in a particular fashion , IRF820 (Mosfet) is connected to the output section of the driver circuit.500V to 600V dc supply is needed to mosfet. For the protection of the mosfet we use the snubber circuit. Snubber circuit is nothing but a combination of resistor and capacitor. The typical circuit diagram of driver connection is shown in fig2 and snubber connection is shown in fig3.

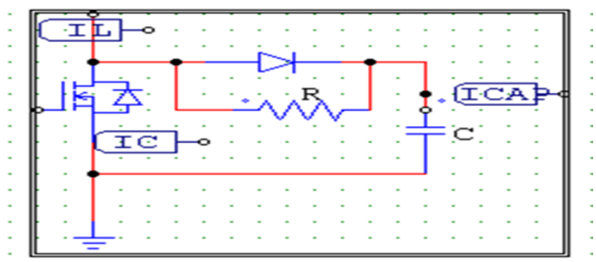

Fig.3 Mosfet connected to the snubber circuit

3. SYSTEM IDENTIFICATION

System identification is done by using MATLAB system identification tool box. Here water bath system is a single input single output system .So the order of the system is one. When we apply the input to the system ,it will take some time for heating process. Similarly when we switch off the system ,it will take some time to come to the initial state. It clearly indicate the transportation delay present in the system. The system identification toolbox figure is shown below.

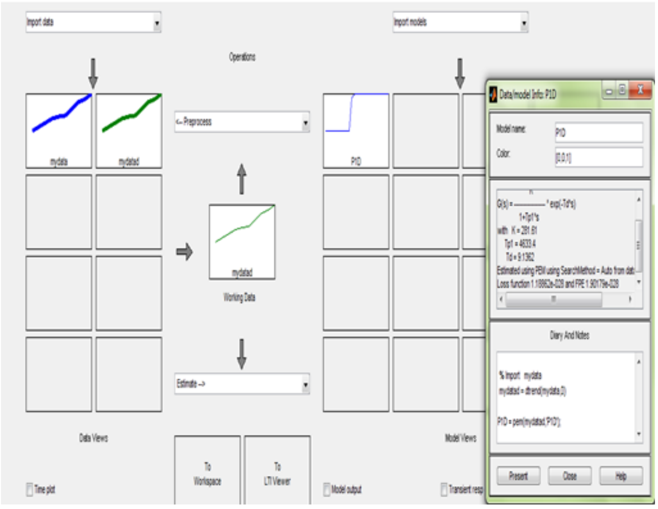

Fig.4 System identification window

The transfer function of the system can be computed as

$$G(s) = \frac{K}{(1 + T_{p1}S)} e^{-T_d s}$$

K= 3.9165

T_{p1}=19.328

Td=30

$$G(s) = \frac{3.9165}{1+19.328s} e^{-30s}$$

TABLE 1: Input and output of the system

Input(Volts)	Output(Degree)
1	65
2	75
2.5	80
3.0	85
3.5	90
4.0	92
4.2	93
4.6	95
4.9	96
5.0	97

3.1 Procedure for system identification

1. Open the matlab
2. Select the input and output variable and give the values
3. Type ident to the command window
4. Select the units
5. Remove the means
6. Shifted data views into the working data.
7. Shifted mydata into the validation data.
8. Select the estimate
9. Select the process model
10. Select the PID graph from the model view

4. DESIGN PROCEDURE FOR FLC

Fuzzy logic control is a control algorithm based on a linguistic control strategy, which is derived from expert knowledge into an automatic control strategy. The operation of a FLC is based on qualitative knowledge about the system being controlled .It doesn't need any difficult mathematical calculation like the others control system. While the others control system use difficult mathematical calculation to provide a model of the controlled plant, it only uses simple mathematical calculation to simulate the expert knowledge. The requirement for the application of a FLC arises mainly in situations where The description of the technological process is available only in word form, not in analytical form. It is not possible to identify the parameters of the process with precision. The description of the process is too complex and it is more reasonable to express its description in plain language words. The controlled technological process has a "fuzzy" character. It is not possible to precisely define these conditions. A fuzzy logic controller has four main components.

4.1 Fuzzification

The first step in designing a fuzzy controller is to decide which state variables represent the system dynamic performance must be taken as the input signal to the controller. Fuzzy logic uses linguistic variables instead of numerical variables. The process of converting numerical variable (real number or crisp variables) into a linguistic variable (fuzzy number) is called fuzzification. This is achieved with the different types of fuzzifiers. There are generally three types of fuzzifiers, which are used for the fuzzification process; they are

1. Singleton fuzzifier

2. Gaussian fuzzifier

3. Trapezoidal or triangular fuzzifier

4.2 Rule Base

A decision making logic which is, simulating a human decision process, inters fuzzy control action from the knowledge of the control rules and linguistic variable definitions . The rules are in "If Then" format and formally the If side is called the conditions and the Then side is called the conclusion. The computer is able to execute the rules and compute a control signal depending on the measured inputs error (e) and change in error (de). In a rule base controller the control strategy is stored in a more or less natural language. A rule base controller is easy to understand and easy to maintain for a non- specialist end user and an equivalent controller could be implemented using conventional techniques.

4.3 Inference Engine

Inference engine is defined as the Software code which processes the rules, cases, objects or other type of knowledge and expertise based on the facts of a given situation. When there I a problem to be solved that involves logic rather than fencing skills, we take a series of inference steps that may include deduction, association, recognition, and decision making. An inference engine is an information processing system (such as a computer program) that systematically employs inference steps similar to that of a human brain.

Fig 5:Real time water bath system implementation

4.4 Defuzzification

The reverse of Fuzzification is called Defuzzification. The use of Fuzzy Logic Controller produces required output in a linguistic variable (fuzzy number). According to real world requirements, the linguistic variables have to be transformed to crisp output. There are many defuzzification methods but the most common methods are as follows :

1) Center of gravity (COG)

2) Bisector of area (BOA)

3) Mean of maximum (MOM)

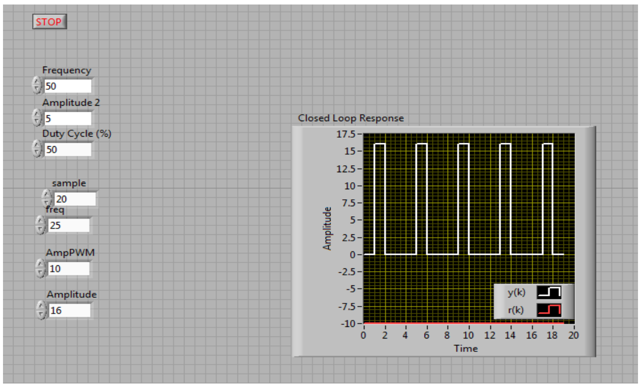

Fig 7:Front panel of PWM generation

5. SIMULATION

The duty cycle of the pulse width modulated wave is varying accordance with the control signal from the controller. PWM generation using LabVIEW blocks are shown in fig 6&7.We can easily pick up the steady state error ,peak time , settling time and other properties of the output response shown in fig.

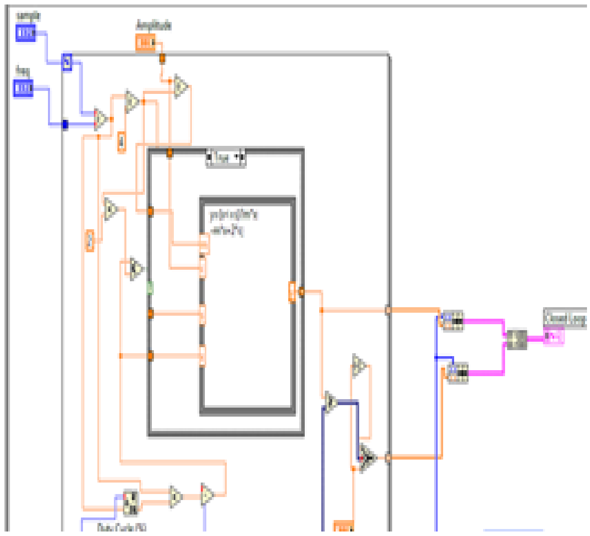

Fig6:Block diagram of PWM generation

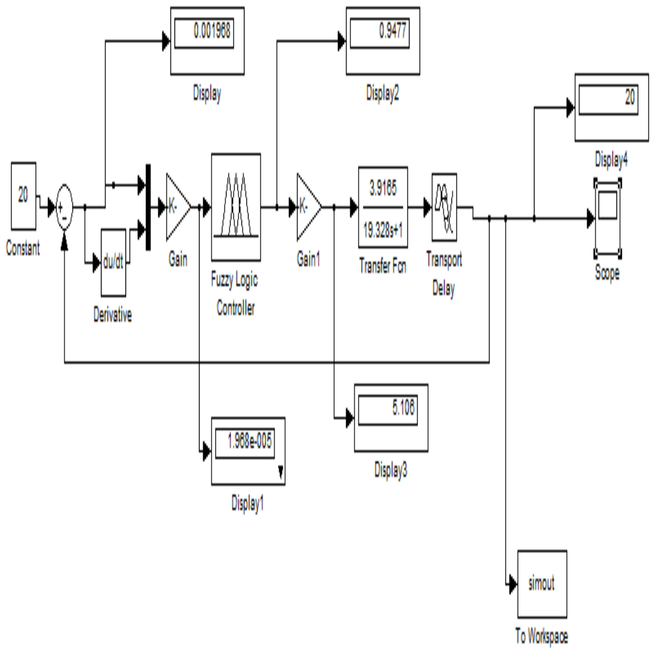

Fig.8 Implementation of fuzzy logic controller

Table.2 Rule base for fuzzy logic controller

U(t)				e(t)				
		NB	NM	NS	ZO	PS	PM	PB
	NB	NB	NB	NB	NB	NM	NS	ZO
	NM	NB	NB	NB	NM	NS	ZO	PS
	NS	NB	NB	NM	NS	NS	PS	PS
Δe(t)	ZO	NB	NM	NS	ZO	ZO	PM	PM
	PS	NM	NS	ZO	PS	PS	PB	PB
	PM	NS	ZO	PS	PM	PM	PB	PB
	PB	ZO	PS	PM	PB	PB	PB	PB

.From the graph It is clear that the system having very long dead time. For the better settling time ,reduce overshoot and steady state error to use self- tuning controller. Response of of normal FLC in MATLAB &LabVIEW are shown in fig8,9,10&11

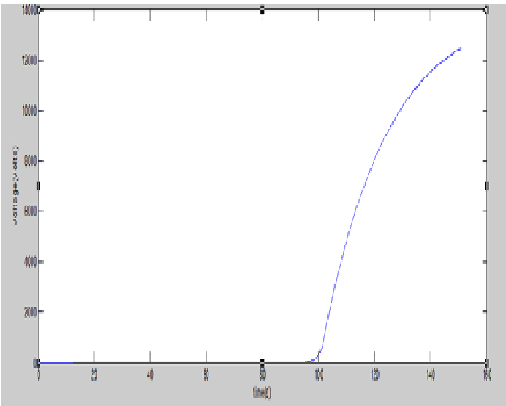

Fig 9: Response of Fuzzy Logic Controller

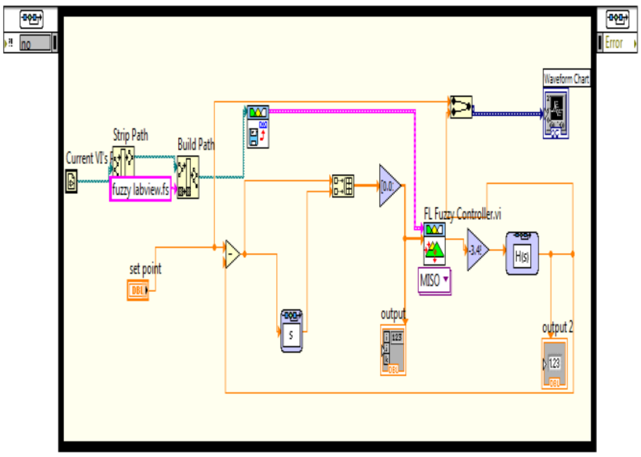

Fig. 10.Block diagram of fuzzy logic controller

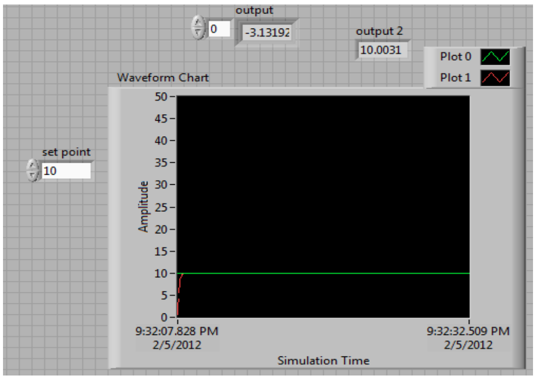

Fig. 11 Front panel of fuzzy logic controller

6. CONCLUSION AND FUTURE WORK

Driver circuit for water bath system was made ,also studied the working .After that design a snubber circuit for the mosfet using the driver circuit. The PCB is prepared for the driver circuit .The system identification is done through MATLAB system identification toolbox. Then system is controlled by normal fuzzy logic controller .After the inference obtained from the response realized that the system having some dead time. My future work is to implement entire system and controller in real time.

7. REFERENCES

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