Chapter – 4

SUMMARY AND CONCLUSIONS

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There are many chemical reactions, industrial processes and experiments, which require temperature to be maintained at a predetermined value. Many ways exist to regulate the temperature, complexity and the cost of the system involved increases with precision and accuracy evaluated for a particular process. There are many modes e.g. ON/OFF, proportional derivative, PID etc. available for control applications. Of late fuzzy logic control systems have became very popular over the conventional control logic for implementing the control, mainly because the process of Fuzzy logic control is, simply to put, the realization of human control strategy, where as conventional controls relay on the mathematical formulations and are involved.

With this idea in mind it was proposed to implement a temperature control system for a small furnace using fuzzy logic and to implement the same to design either a microprocessor or a microcontroller based system, with the required driver for the control of the furnace. It was also proposed to employ triangular type of membership functions for both input and output variables and height defuzzification method to get crisp output value. To implement this the entire work is divided into four chapters.

Chapter I- begins with history of fuzzy logic and it is followed by explanation of crisp and fuzzy sets, advantages and disadvantages of fuzzy logic have been given and the application of fuzzy logic for the consumer products have been tabulated. This chapter contains discussion on

1. Methods of fuzzification.
2. Methods of defuzzification.

At the end of this literature survey is given in which summary of work done by some workers on temperature control systems employing fuzzy logic has been given. At the end of the chapter references are given.

Chapter II- : gives general description about transducers used for measurement of temperatures and their principle of operation with typical applications. Important parameters associated with the transducers have been discussed which is followed by their classification. The transducer covered in this chapter include RTD, thermocouple, semiconductors, pyrometer and thermistor. Advantages and disadvantages thermistor and thermistor characteristics for the thermistors with resistance values of 4k7, 3k3, 2k2, 1k have been given. In the design of sensor section a novel IC 555 based astable multivibrator is designed both using conventional method and fuzzy approach. Thermistor forms a part of RC timer section the frequency of multivibrator varies with temperature. The design by conventional method includes analytical as well as graphical approaches. A formula relating R and

C with the pulse width has been derived. The same design has been worked out by fuzzifying the frequency and the time constant RC and developing membership functions for them. IF-THEN rules have been constructed to incorporate fuzzy reasoning. IC 555 is used to give frequency of 140 Hz at room temperature and graph of frequency as a function of temperature is plotted to check the linearity. The results of conventional and fuzzy methods have been compared at the end. At the end of the chapter references have been given.

Chapter III – begins with a general block diagram of fuzzy temperature controller. Which is followed by the system block diagram of fuzzy logic temperature controller. The details of the hardware used have been covered in the discussion. Zero crossing detector is employed to fire the triac circuit at the zero of AC input and the details of the circuits have been also given. Various labels such as VVL,NL, L, LL, ML, N,H etc. have been used to describe triangular type of fuzzy sets and their meanings are explained with the range of temperature and the count values associated with each of them. The following steps have been implemented for fuzzifying and defuzzifying input and output variables.

Step 1 :- Defining input and output for fuzzy logic controller.

Universe of discourse for input and output is from room temperature to 100^0C and the pulse width modulation is from 20 to 80 %. The temperature is measured as a function of frequency and the count corresponding to the frequency is measured by microprocessor based system, which stores this count. The microprocessor works as fuzzy logic controller using this count as input variable and accordingly decides the value of the duty cycle to be output to the controller.

Step 2. Fuzzification of input variable.

Triangular type of membership function have been used to fuzzyfy the input temperature and labels such as VVL, VL etc. have been given to the fuzzy sets. The temperature is represented as count which is also fuzzified using standard seven fuzzy sets and labels such as VVLC, VLC etc. have been used to describe these fuzzy sets. The output is the duty cycle. Which has been fuzzified in a similar manner.

Rule base :

Ours is single input and single output system and hence simple IF – THEN rules is used as a rule base, e.g. one such rule is

IF temperature is H THEN duty cycle is SD.

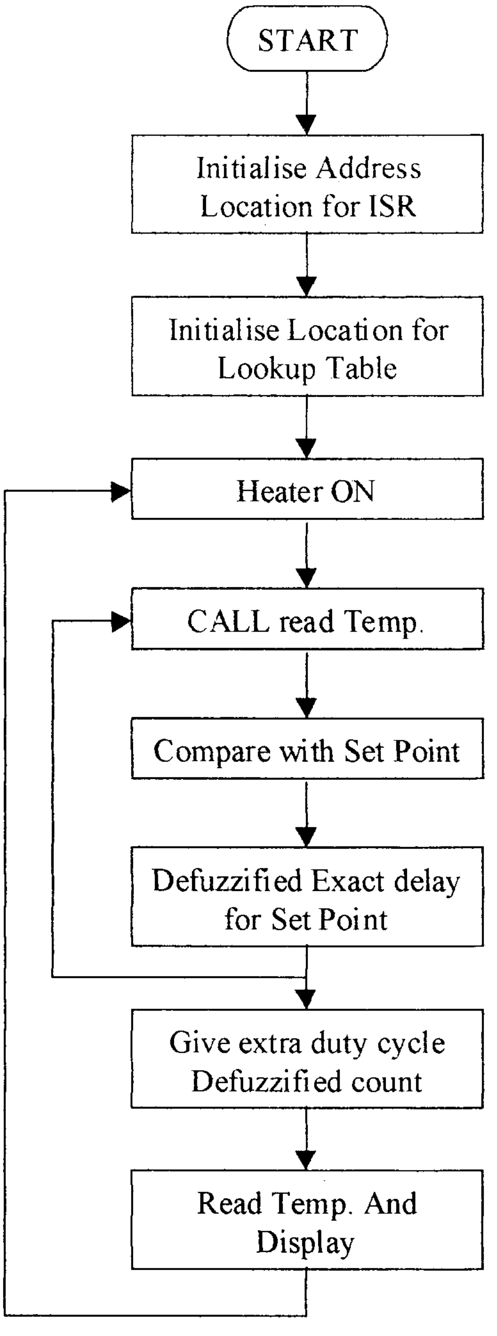
Where H- means high temperature and SD means small duty cycle.

Each fuzzy input variable will activate one fuzzy output rule and duty cycle modulation will accordingly.

Defuzzification of outputs :

In order to get the duty cycle as a crisp value height defuzification method has been used.

The software implementation begins with the flowchart of the entire system. Which is given belcw.



This program after initialization of 8255 as O/P device calls the heater-on program corresponding to the room temperature ON and OFF time i.e. fuzzified counts from the table.

The comparison with the defuzzified count corresponding to the set-point fires the rule and accordingly ON and OFF times (counts) get modulated till the set-point temperature is attained. At this stage the defuzzified counts corresponding to the ON and OFF times are evaluated and the heater power is controlled to maintain the temperature constant. The temperature is displayed and the entire process repeats.

Various assembly language routines have been developed to implement the flow chart. Look up tables have been constructed to store the hex count corresponding to temperature and hex count corresponding to the on time and off time of pulse.

To test the performance of system two temperatures namely 50^0C and 80^0C were selected and tuning process was employed to select suitable duty cycle to get the temperature near the set point value. The scaling factor for the purpose of turning 1.072 and the width of temperature domain was 5. It has been concluded that (1) the temperatures are exactly near the set point when duty cycle is 50%. (2) Results are satisfactory if the set point is higher (80^0C).

This is evidence by the observations given in following tables :

I) Set point 80^0C

Table I

Set	% Duty cycle	Steady state temp.
V	60 %	98^0C
I	55 %	87^0C
II	50 %	81^0C
III	45 %	78^0C
IV	40 %	76^0C

II) Set point 50^0C

Table II

Set	% Duty cycle	Steady state temp.
I	70 %	80^0C
II	65 %	78^0C
III	60 %	65^0C
IV	55 %	60^0C
V	50 %	53^0C

It is possible to implement self tuning process by fixing the variation of set-point within particular range e.g. $80^0 \pm 1^0C$ and change the look-up table should deviation occur beyond the range in order to output the exact count corresponding to the required set-point value.