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Microcontroller based Intelligent Temperature Controller for Greenhouse

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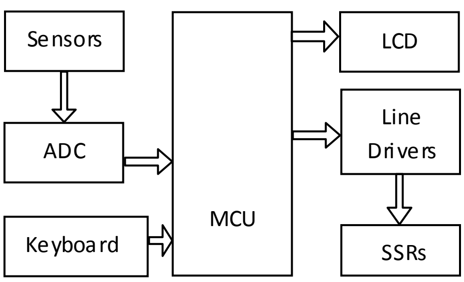
ABSTRACT – *This paper deals with the design and implementation of an Integrated Fuzzy Logic Controller (IFLC) for temperature control in greenhouse. The proposed controller employs an architecture that is an integration of Fuzzy logic and PID controller. The controller can handle two inputs, two outputs and 27 fuzzy rules. The PWM outputs were generated to control the temperature according to the set point value.*

Keywords - Digital PID, FLC, Fuzzy Logic, IFLC, Integrated Fuzzy Logic

I. Introduction

The classical definition of greenhouse is a structure that is covered with a material that is transparent to the visible portion of the electromagnetic spectrum, which is utilized in the growth of plant. The performance of the greenhouse is best when temperature is not too hot and not too cold. It is necessary to maintain suitable temperature at growth stage of several plants. So, with the controlled environment in the greenhouse it is possible to increase the quality and quantity of crop produce per unit land in minimum possible time [1][2][3]. Automation in greenhouse is very important for successful management of the greenhouse crops. There are many conventional methods for controlling greenhouse temperature but are less effective since they are either based on on-off control or proportional methods. Fuzzy control has been widely applied in industrial controls and domestic electrical equipment[4]. The automatic learning of fuzzy rules is a key technique in fuzzy control. To enhance the performance the fuzzy logic controller is integrated with PID. In the present design a controller was designed which would sense the inside and outside temperature of greenhouse, displays it on the screen, allows user to set inside temperature as per the requirement and activate the cooling or heating system accordingly. An integrated fuzzy logic[5][6] approach was used to decide the output.

1. SYSTEM BLOCK DIAGRAM



The complete system can be implemented using a good combination of hardware and software.

2.1 HARDWARE

The system hardware was designed using Atmel's 89C52 microcontroller as an MCU, which initialize the system, reads the sensors, displays the values on LCD and take action according to the algorithm. The LM 35 ICs were used to sense the inside and outside temperature of the greenhouse whose outputs were converted to digital using 8-bit A/D converter IC. A 20x4 LCD display module was used to display the current values of the temperature. This module has four rows of twenty characters in each row. The reason behind selection of this module was to have better interactivity between the user and the hardware so that messages could be easily displayed on the screen, which could be understood by the user. The port 2 pins P2.5 and P2.6 were used for controlling the heating and cooling systems. These lines were connected to the solid-state relays through line driver IC ULN2808. The cooling and heating systems were connected to these solid-state relays so that PWM output can be generated for these systems.

2.2 SOFTWARE

The software was developed using assembly language. The concept of modular programming was used so that system could be easily upgraded. The major software modules developed were-

a. Initialization Module
b. Sensor module
c. Keyboard and display module
d. IFLC module
e. PWM generation module

After reset, the initialization module loads the variables, stack, and other necessary registers to their default values set by the programmer, initialize the timers and start them. The sensor module sense the inside and outside temperature one by one, converts it to digital and stores them to the corresponding location. The keyboard and display routine allows the user to set the inside temperature and displays the settings and temperature values on the LCD. The IFLC module is discussed in section 3. The PWM outputs were generated for the cooling and heating system by PWM generation routine using timer 1 interrupt of 89C52.

II. INTEGRATED FUZZY LOGIC CONTROLLER (IFLC)

In the present design, an integrated fuzzy logic controller (IFLC)[5][6][7] was used for maintaining the temperature of the greenhouse to the desired point. The IFLC is an integration of an intelligent fuzzy logic controller and the PID controller. The block diagram of integrated fuzzy logic controller is shown in Fig. 3.1

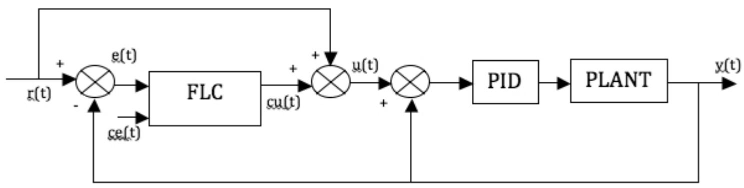


Figure 3.1 block diagram of IFLC

IFLC basically requires an FLC and a PID controller. An FLC was designed to which two input variables e_{temp} and ce_{temp} were given. The e_{temp} is the error value of temperature, which was computed as

e_{temp} = temperature set point - current value of temperature and change in error ce_{temp} is computed as-

$$ce_{temp} = \text{current } e_{temp} - \text{previous } e_{temp}$$

Both of these values are crisp in nature, which needs to be converted to fuzzy values. The error value of temp e_{temp} was fuzzified using triangular membership function within the universe of discourse with nine linguistic values, as shown in Fig. 3.2, the linguistic values were NVL (Negative Very Large), NL (Negative Large), NM (Negative Medium), NS (Negative Small), Z (Zero), PS (Positive Small), PM (Positive Medium), PL (Positive Large) and PVL (Positive Very Large). The universe of discourse for error was (-40, +40) ^{0}C.

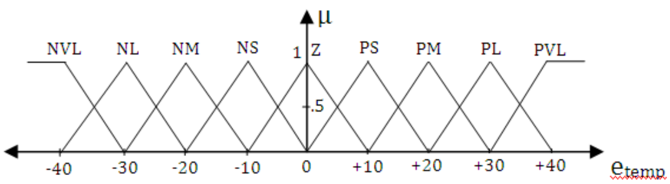


Figure 3.2 Membership function for error

The change in error ce_{temp} was also fuzzified using triangular membership functions with three linguistic values NEG (Negative), Z (Zero) and POS (Positive), as shown in Fig. 3.3.

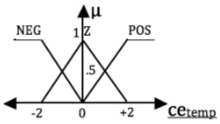


Figure 3.2 Membership function for change in error

The decision making stage consists of fuzzy rules which decides what action to be taken. This is the main block of the fuzzy control and constructed from the expert knowledge and experience. The rule base was designed on the basis of knowledge from experts and literature, which consists of 27 rules, as shown in Table 3.1.

Table 3.1 fuzzy logic rule base

ca / e / ce	NVL	NL	NM	NS	Z	PS	PM	PL	PVL
NEG	VH	H	LH	M	VL	M	LH	H	VH
Z	VH	VH	H	LH	VL	LH	H	VH	VH
POS	VL	VL	VL	VL	VL	VL	VL	VL	VL

The selection of either cooling or heating system was based on the error value. If error is positive the heating system will be selected otherwise cooling system was selected and control action would be applicable to selected system.

The general form of fuzzy logic rule is:

IF (condition 1) AND (condition 2) THEN (action)

For example, IF e_{temp} is PS AND ce_{temp} is POS then control action is VL. This process is known as inference. The inference process relates the fuzzy state variables e_{temp} and ce_{temp} to the fuzzy control action ca_{temp}. The control action is also fuzzified using triangular membership function as shown in Fig. 3.4 and has linguistic values VL (Very Low), L (Low), M (Medium), LH (Little High), H (High) and VH (Very High).

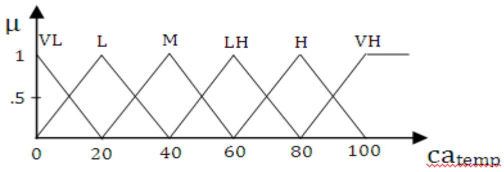


Figure 3.4 membership functions for control action

The fuzzy inference engine processes the input data and computes the control outputs using IF-THEN rules. The fuzzy rule-based Mamdani inference[4][8] is shown in Fig. 3.5. These outputs are fuzzy values, which are then converted to crisp value in defuzzification stage.

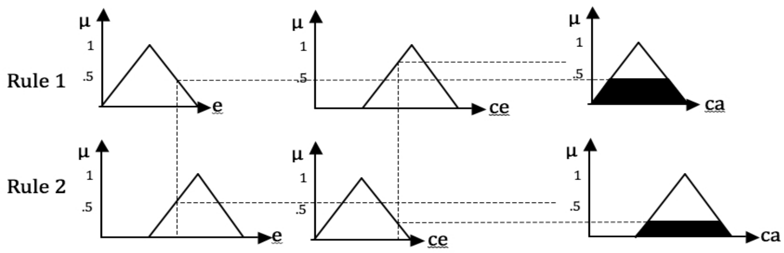


Figure 3.5 Fuzzy inference

Defuzzification:

To convert the fuzzy values obtained by decision-making stage into non-fuzzy or crisp value, the Center Of Gravity (COG), also known as Center Of Area or Centroid, method was used. This method has proves to work well with efficient an accurate results[9]. The defuzzified output for the process is calculated by using the equation-

$$y = \frac{\sum_{k=1}^{n} \mu(y_i) \times y_i}{\sum_{k=1}^{n} \mu(y_i)}$$

Where,

y : control action by FLC
k : No. of fuzzy variables
yi: Peak value of ith clipped fuzzy set
μ(yi): Membership value of ith clipped fuzzy set

The defuzzification is shown in Fig. 3.6.

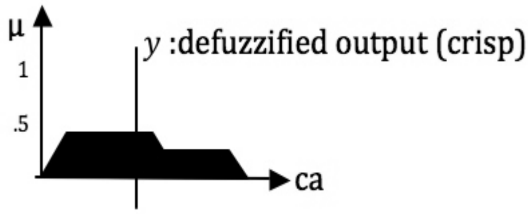


Figure 3.6 defuzzification

The crisp value obtained from defuzzification stage for the corresponding values of e_{temp} and ce_{temp} were scaled and stored in the internal ROM as look up table and the values of e_{temp} and ce_{temp} were used to access these crisp values from the look up table. The value read from the look up table was added to the temperature set point and it was treated as the new set point for PID controller as shown in Fig. 2.23. The current temperature value was subtracted from the new set point value and the difference was considered as error value e_n for PID controller. The PID controller generates the new control action v_n implemented using the velocity equation[6][7]-

$$v_n = v_{n-1}+kp(e_n-e_{n-1})+ki(e_n)T+kd/T(e_n-2e_{n-1}-e_{n-2})$$

where,

v_n: Control action by PID controller
v_{n-1}: previous control action
e_n: current error value of PID controller
e_{n-1}: previous error value of PID controller
e_{n-2}: previous to previous error value to PID controller
kp: proportional gain
ki: integral gain
kd: differential gain
T: cycle time

For the present controller, the values of kp, ki and kd were finalized as 2, 1 and 1 respectively. After reset, previous values of error and v_n were initialized to zero. The value computed by the above equation was scaled within the limits and the scaled value was used for calculation of percentage duty cycle for PWM output, which was generated using timer 1 ISR. The PWM output was used to control either cooling or heating system depending on the error value e_{temp}. The above procedure was repeated to maintain the temperature of greenhouse as per the set point. The PWM waveforms are shown in fig.3.7.

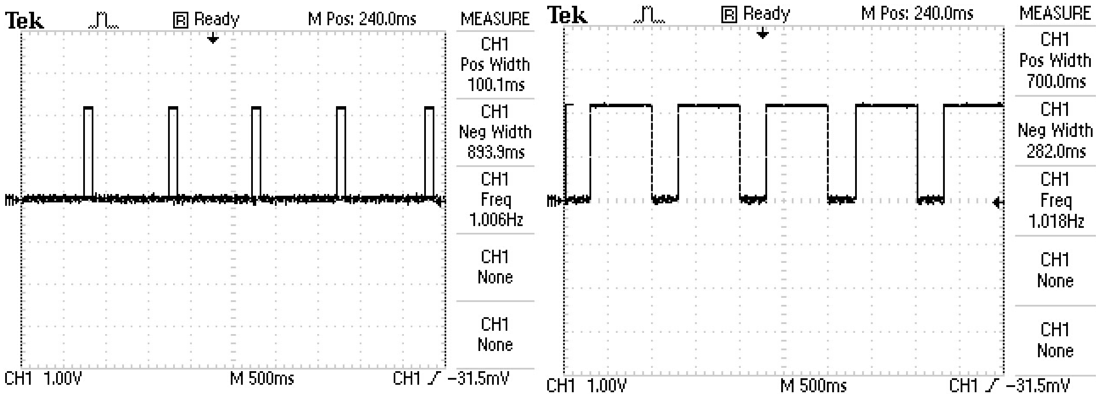


Figure 3.7 PWM waveforms for 10 and 70 % duty cycle

III. CONCLUSION

After designing the hardware and development of complete software the functioning of the system was checked. After reset, the system displays the welcome message and the various parameters on the LCD screen. The keyboard routine functioning was verified by making the changes in the set point value, once the set point is made the controller acts accordingly and in the background the IFLC routine generates the PWM outputs necessary for maintaining the set temperature in the greenhouse where as the sensor and the display routines displays the latest data on the screen. The IFLC shows best performance in maintaining the temperature of greenhouse with very little variations.

REFERENCES

[1] A. Sriraman and R. V. Mayorga, A Fuzzy Inference System Approach for Greenhouse Climate Control, *Environmental Informatics Achieves, Vol. 2(2004), pp699-710.*

[2] ZHOU Xiaobo, WANG Chengduan and LAN Hong, The Research and PLC Application of Fuzzy Control in Greenhouse Environment, *2009 Sixth International Conference on Fuzzy Systems and Knowledge Discovery, pp340-344.*

[3] R. Caponetto, L. Fortuna, G. Nunnari and L. Occhipinti, A Fuzzy Approach to Greenhouse Climate Control, *Proceedings of the American Control Conference Philadelphia, Pennsylvania, June 1998, pp1866-1870.*

[4] John Yen, Reza Langari, *Fuzzy Logic Intelligence, Control and Information* (Pearson Education, 2003).

[5] Ming-Yuan Shieh and Tznu-Hseng S. Li, Integrated Fuzzy Logic Controller Design, *IEEE 1993, pp279-284.*

[6] S. S. Patil and P. Bhaskar, Design and Real Time Implementation of Integrated Fuzzy Logic Controller for a High Speed PMDC Motor, *International Journal of Electronic Engineering Research, Vol.1 No.1 (2009), pp13-25.*

[7] S. S. Patil, P. Bhaskar and L. Shrimanth Sudheer, Design and Implementation of An Integrated Fuzzy Logic Controller for a Multi-Input Multi-Output System, *Defence Science Journal, Vol. 61, No. 3 May 2011, pp219-227.*

[8] Timothy J. Ross, *Fuzzy Logic with Engineering Applications* (Wiley-India, 2005).

[9] Scott S. Lancaster and Mark J. Wierman, Empirical Study on Defuzzification, *IEEE (2003), pp121-126.*