Temperature Optimization by Fuzzy Logic AC Voltage Control

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ABSTRACT
Fuzzy Logic is used to implement a wide variety of intelligent control strategies. Fuzzy logic is a concept in which imprecise data can be processed precisely manner. There is variety of applications falling under three categories: Software Simulation, Software embedded in the Hardware and Total Hardware implementation. A simple application of Fuzzy Logic belonging to the second category is reported in the present paper. The hardware design based on 8-bit PIC microcontroller intends to control the AC voltage with FLC implemented through software. The fuzzy logically firing angle of thyrister is optimized to control the AC voltage. The Fuzzy Logical AC voltage control form the driving signal for physical parameter control such as temperature, pressure, speed of motor etc.

Keywords
Fuzzy Logic, AC Voltage Control, PIC, Temperature.

1. INTRODUCTION
Fuzzy sets are functions that map a value, which might be a member of a set, to a number between zero and one, indicating its actual degree of membership. Fuzzy logic is a form of many-valued logic or probabilistic logic; it deals with reasoning that is approximate rather than fixed and exact. In contrast with traditional logic they can have varying values, where binary sets have two-valued logic, true or false, fuzzy logic variables may have a truth value that ranges in degree between 0 and 1. Basically, Fuzzy Logic (FL) is a multivalve logic that allows intermediate values to be defined between conventional evaluations like true/false, yes/no, high/low, etc. People do not require precise, numerical information input, and yet they are capable of highly adaptive control. Fuzzy logic is a concept in which imprecise data and vague terms can be processed in precise manner. The FLC is operated by knowledge-based algorithm. Fuzzy logic control can be used to implement a wide variety of intelligent functions including everything from Storage of Low Temperature Biomedical Product, Consumer Electronic and Household Appliances to Auto Electronics, Process Control, Instrument Temperature Management, Room Temperature Management, and Industrial Automation.

The AC voltage control by implementation Fuzzy Logic Control basically controls the load voltage of half converter. The gate pulse of Thyrister is controlled by microcontroller. The basic block diagram of the system is shown in the fig.1.

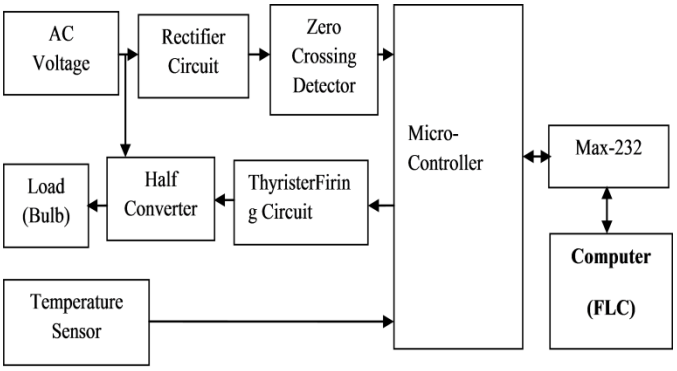


Fig 1: Basic block diagram of AC voltage Control

The input of the system is temperature, which is given to the controller. The Thyristor Firing Unit (TFU) is a module which detects a sinusoidal voltage. The sinusoidal voltage passes through zero line followed by an adjustable delay, provides a firing pulse. This pulse is designed to trigger, that is to cause the thyrister to conduct when the anode-cathode voltage is positive. Simple single-phase half-wave controlled rectifier is built with a Thyrister Firing Unit and a Power Thyristor Module. The TFU is made up of pulse transformer and transistor. The time interval tα represents the delay from the zero-crossing of the sinusoidal voltage waveform to the start of the pulse which triggers the thyrister. Usually, this delay is expressed as an angle and is called the angle of retard, or firing angle, α. The delay variables α and tα are related by the equation (1).

$$\propto = \frac{t_a \times 360^0}{T} \qquad (1)$$

Where, T is the total period of the sinusoidal supply voltage, tα is delay time, α is firing angle

When the TFU is used to control the firing angle of thyrister, in a circuit powered by a source with frequency 50 Hz, equation (1) becomes equation (2)

$$\propto = \frac{t_a \times 360^0}{0.02} \qquad (2)$$

The Tx and Rx pin of the PIC are connected to max-232IC. The max 232 used for serial communication with computer. 'Micro-C' software is used to develop the burn program for PIC microcontroller. Fuzzy Logic Processing Module is created using MATLB programs.

2. SOFTWARE DEVELOPMENT

2.1 PIC program

The serial communication program of the PIC microcontroller with unsigned floats a, b, k is listed as follows-

```
void main()
{
  TRISA =0xFF; //port a as a input port.
  TRISB =0x00 ;  // port b as a output.
  TRISC=0x80; //portc.f7 is output pin.
  a = Adc_Read(0); //Conversion of ADC value.
 Usart_Init(9600); Select 9600 baud rate.
 while (1)
 {
  if (b=a/2);
  {
    Usart_Write(b); // send received value serially
  }
   if (Usart_Data_Ready()) // Data available
  {
     k = Usart_Read();// Receive data computer
                              to µp
    Portb.f1=k;
    Delay_ms (2)
    Portb.f1=0
   Delay_ms (8)
    }
  }
}
```

2.2 MATLAB program

The serial communication program of the

MATLAB is listed as follows-

```
SerPIC = serial ('COM1'); %-- select COM one.
Set (SerPIC,'BaudRate', 9600, 'Data Bits', 8,
'Parity', 'none','StopBits', 1,
'Flow  Control', 'none');%-- select baud rate bit.
fopen (SerPIC); %--open the serial port to the PIC.
for i = 1:2000; %--loop.
b= fread (SerPIC,1,'uint8'%--accepted value read.
out = b %--Display.
simpract; %te,[1 is name of model] %-- Accepted
                          data send  to the Model.
k=round (k) %--output of the model receive data
                  and  display it.
fwrite (SerPIC,k); %--Data send to pic
                       microcontroller.
end
fclose(SerPIC);
```

3. FUZZY LOGIC CONTROL (FLC)

Fuzzy Methodology involves the steps as shown in figure.2.

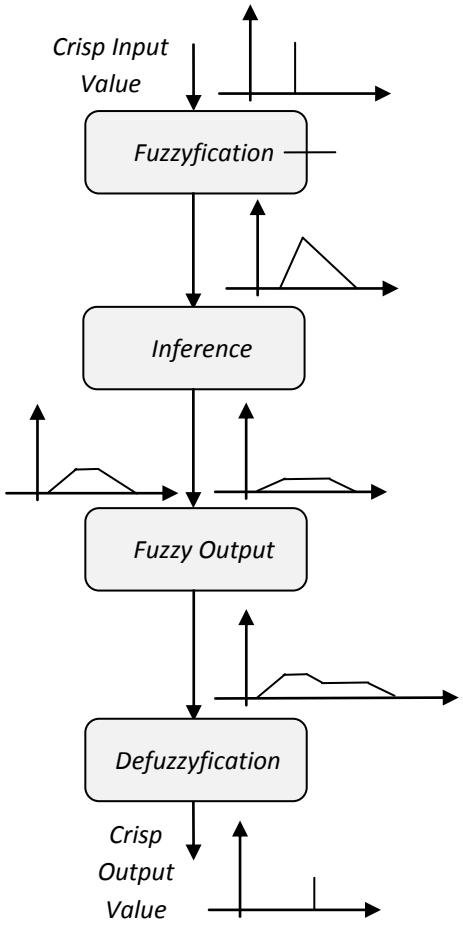


Fig 2: Steps of Fuzzy Methodology

A. Crisp Value

Crisp value is nothing but the present temperature.

B. Fuzzification

Fuzzification means the crisp value is converted into Fuzzy input value with help of suitable membership function (In the present work the combination of triangular and trapezoidal membership functions have been employed).

C. Inference Mechanism

Defines different type Fuzzy Rules in the form of If-Then for temperature control have been devised based on the priori system knowledge.

D. Fuzzy Output

It is nothing but the output membership value that Clips the output variable Fuzzy Set for each active rule invoked from the rule base there by generating the Clipped Fuzzy Sets.

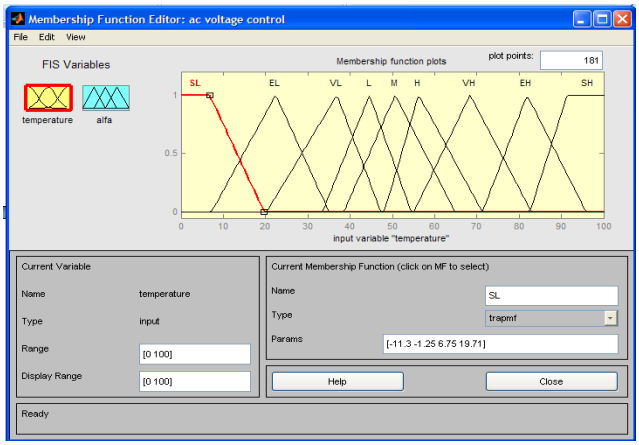
E. Defuzzification

Defuzzification means to compute the final output (AC voltage) with the help suitable defuzzification method. In present work, we have used Centre of Gravity (COG) for Defuzzification to obtain the load AC voltage.

The FIS (Fuzzy Inference System) is created firstly using fuzzy toolbox and exported to the workspace. This is priori created for simulation model in MATLAB.

3.1 Input fuzzification

Temperature is the input variable for FLC. The range of



temperature is 0 to100^{0}C.

Fig 3: Input membership function temperature

The signal is partitioned in to nine regions entailing to nine membership functions labelled as: Super low, Extremely low, Very low, Medium, High, Very high, Extremely high and Super high as depicted in figure 3.

3.2 Output fuzzification

The range of Alfa is 0 to 20.The variable Alpha is partitioned in to nine regions entailing to nine membership functions labelled as: Super minimum, Extremely minimum, Very minimum, Maintain, Maximum, Very maximum, Extremely Maximum and Super maximum as shown in figure 4.

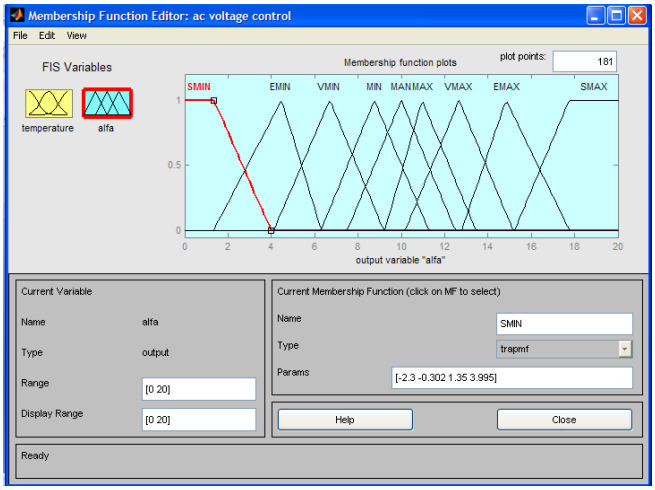


Fig 4: Output membership function Alfa

3.3 Fuzzy Rules

The control strategy is formulated in terms of Fuzzy Inference Rules enlisted as follows-

R1: IF Temperature is Super low THEN Alfa is Super minimum

R2: IF Temperature is Extremly low THEN Alfa is Extremly minimum

R3: IF Temperature is Very low THEN Alfa is Very minimum

R4: IF Temperature is low THEN Alfa is minimum

R5: IF Temperature is Medium THEN Alfa is Maintain

R6: IF Temperature is High THEN Alfa is Maximum

R7: IF Temperature is Very high THEN Alfa is Very maximum

R8: IF Temperature is Extremely high THEN Alfa is Extremely maximum

R9: IF Temperature is Super high THEN Alfa is Super maximum

3.4 Defuzzyfication

The process of Defuzzification shown in fig.5.

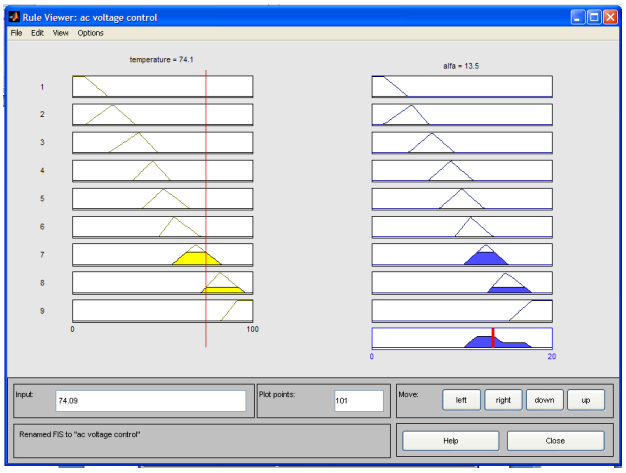


Fig 5: Fuzzy inference and Defuzzyfication

3.5 Surface View of AC voltage control

The graph between Temperature and Alfa is shown in figure 6.

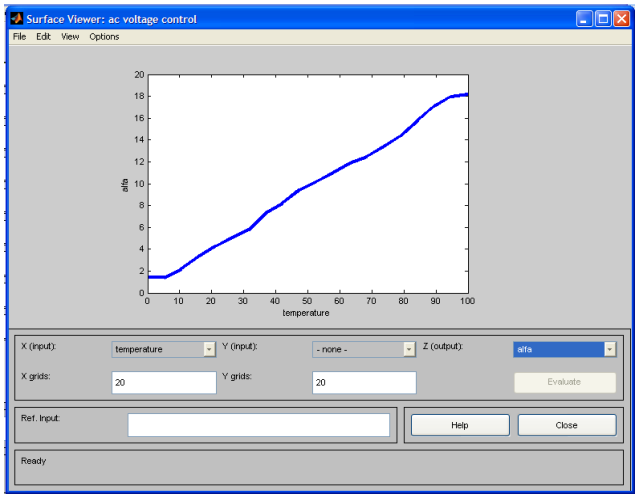


Fig 6: FIS Surface view

3.6 MATLAB simulation Model

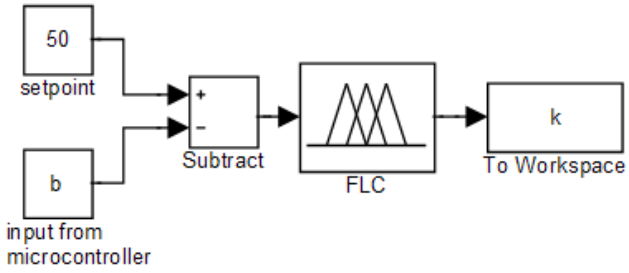


Fig 7: MATLAB Simulation Model

Construction of the model shown is in figure 7. The one input is 50, which is set point temperature and other input is b, which is output of the PIC going to the simulation model created using Simulink facility of MATLAB residing on the computer. The error between Set point and input b triggers the FLC activating the fuzzy rules. The output of the FLC goes to Workspace. From workspace Fuzzy calculated data is directly transferred to PIC with the help of MATAB program routine that is used to control the firing angle of thyrister.

4. Conclusion

The paper presents a computer based Fuzzy Logic way to optimize the temperature through Electronics Design. However the exact directions and extent of future developments will be dictated by advancing technology and market forces. Fuzzy logic is a tool and can only useful and powerful when combined with Analytical Methodologies and Computer Reasoning Techniques.

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