A Study on Voltage Regulation using Fuzzy Analysis

Arul Jeya Shalini[1], C. Karthika[2]

[1, 2]*PG Department of Mathematics, Women's Christian College, Chennai– 600 006, India*

***Abstract* — A fuzzy logic controller (FLC) [1] with fast reference watts generation to correct and regulate unbalance watts in three-phase system is proposed in [2]. We designed an efficient algorithm to regulate the unbalance watts in three-phase system under different conditions of the utility supply. In our simulation test, the Fuzzy Logic control shows consistent excellence under various operating conditions such as different initial control gains, different load levels, and change of transmission network and consecutive disturbances. As a result we theoretically reduce the electricity bill to minimise the watts and voltage usage.**

***Keywords* — Fuzzy Logic Control, Voltage Unbalance, sample circuit board, generator.**

I. INTRODUCTION

The idea of fuzzy logic was first given by Lotfi Zadeh of the University of California at Berkeley in the 1960s. While working on the problem of computer understanding of natural language which is not easily translated into the absolute terms of 0 and 1. Fuzzy Logic is a powerful problem solving methodology with a lot of embedded control and information processing. Fuzzy Logic provides a remarkable way to draw definite conclusions from vague, ambiguous or imprecise information. Fuzzy Logic resembles human decision making with an ability to work from approximate data and to find precise solution. Fuzzy sets have been suggested for handling the imprecise real world problems by using truth values range between "true" or "false".

To implement fuzzy logic technique [1] in a real time application requires the following three steps: (a) Fuzzification – Convert classical data or crisp data into fuzzy data or membership functions (MFS). (b) Fuzzy Inference Process – Combine membership functions with the Control rules to derive the fuzzy output. (c) Defuzzification – use different methods to calculate each associated Output and put them into a table. Fuzzy control rule [4] can be considered as the knowledge of an expert in any related field of application. The fuzzy rule is represented by a sequence of the form IF-THEN. A fuzzy IF-THEN rule associates a condition described using linguistic variables and fuzzy sets to an output or a conclusion. In this paper we reduce the electricity bill by managing the voltage fluctuation.

II. ELECTRICITY CONSUMPTION

There are two electric appliances that consume current in different way. One is the without motor appliances which consume less current and if there is less voltage supply these appliances can work. Appliances without motor are bulbs, tube lights, water heater, laptops and phones. The other is with motor appliances which consume more voltage to work. Appliances with motor are air conditioner, refrigerator, fan; mixer, pumps and computer labs. Fan has larger operating voltage. Air conditioner has small operating voltage. All the electrical appliances require 230 volts to 240 volts to work.

1) FUZZIFICATION AND INFERENCE

Fuzzy logic uses linguistic variables [5] instead of numerical variables. In the real world, measured quantities are real numbers (crisp). The process of converting a numerical variable (real number) into a linguistic label (fuzzy number) is called fuzzification. The inputs are mapped into these membership functions and a degree of membership is found for how much the input belongs to that particular linguistic label. The membership can take on a value from zero to unity for each of the linguistic labels. The waveforms are evenly distributed about the range of operation of the variables. Once the membership is found for each of the linguistic labels, an intelligent decision can be made unto what the output should be. This decision process is called inference.

2) DEFUZZIFICATION

In conventional controllers, there are control laws, which are combinations of numerical values that govern the reaction of the controller. In fuzzy logic control, the equivalent term is rules. Rules are linguistic in nature and allow the operator to develop a control decision in a more familiar human environment. After the rules are evaluated, each output membership function will contain a corresponding membership. From these memberships, a numerical (crisp) value must be produced. This process is called defuzzification.

3) CONDITION FOR THE GRAPH

Input values should touch the upper triangle and the lower triangle region. And the two points touching the triangle are said to be $x_1 and\ x_2$ then

$$(\,Peak\ value\ of\ \ x_1\ \times Membership\ value\ of\ \ x_1\,) + (\,Peak\ value\ x_2 \times Membership\ value\ of\ x_2\ ) = out\ put\ value$$

That is, $P_{x_1}\,\mu_{x_1} + P_{x_2}\,\mu_{x_2} = out\ put\ value$

4) ALGORITHM FOR THE INFERENCE VALUES

Step 1: Given n output we check from $n/_2$ value for watts regulation and $n/_4$ value for voltage regulation.
Step 2: We get the membership value at the corresponding $n/_2$ value.
Step 3: To the membership value we choose the corresponding peak value.
Step 4: We use the formula $P_{x_1}\,\mu_{x_1} + P_{x_2}\,\mu_{x_2} = out\ put\ value$
Step 5: If the output value is not approximate to the n value again then proceed from step 2 for the next values.

III. ILLUSTRATION FOR WATTS REGULATION

Peak value in the graph are said to be the power saver values. We define seven linguistic variables for the graph. The linguistic variables are Negative, Nearly Zero, Positive Minimum, Positive Small, Positive Medium, Positive Large and positive Maximum. It has been separated accordingly and it is mentioned with the help of colours. According to the crisp input value it approximately lies in the positively large and positively maximum region.

Illustration 1

Step 1: $n = 13KW$; $n/_2 = 7KW$

The graph for Crisp input = 7KW is

Step 2: The corresponding linguistic regions for 7KW are found to be positively large and positively maximum as shown in Figure 1. As their membership values are 0.856 and 0.478.

Step 3: The corresponding peak value for membership value 0.856 is 8 and for membership value 0.478 is 10.

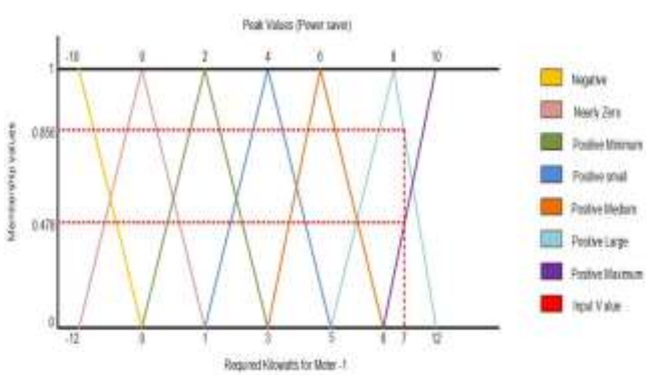

Fig 1 Skewed triangular graph ($for\ x = 7$)

Step 4: $P_{y_1}\,\mu_{y_1} + P_{y_2}\,\mu_{y_2} = out\ put\ value$

$$P_{y_1}\,\mu_{y_1} \Longrightarrow 0.478 \times 10 = 4.78$$
$$P_{y_2}\,\mu_{y_2} \Longrightarrow 0.856 \times 08 = 6.85$$
$$output\ value = 11.628$$

Step 5: Crisp output 11.628 is not equal to the required output so we proceed with next illustration where the crisp input value 8KW.

Illustration 2: The graph for 8KW is shown in Figure 2.

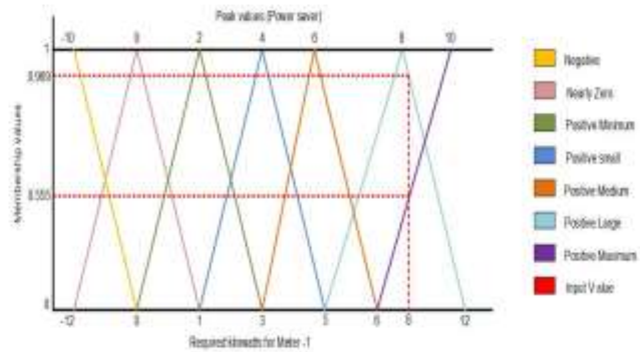

Fig 2 Skewed triangular graph (for x = 8)

Table 1 Membership values $(for\ x = 8)$

FUZZY SETS	INPUT SETS	OUTPUT SETS	OUTPUT COMPONENT
Negative	0	-10	0
Nearly Zero	0	0	0
Positive Minimum	0	2	0
Positive Small	0	4	0
Positive Medium	0	6	0
Positive Large	0.969	8	7.752
Positive Maximum	0.555	10	5.55

The crisp output value is 13KW. It is obtained with the help of the formula $P_{y_1}\,\mu_{y_1} + P_{y_2}\,\mu_{y_2} = out\ put\ value$

$$P_{y_1}\,\mu_{y_1} \Rightarrow 7.752$$
$$P_{y_2}\,\mu_{y_2} \Rightarrow 5.55$$
Output Value=13KW

When the crisp input value is 8 Watts we get the output value as 13 Watts, by this we reduce the electricity consumption and we can minimize the electricity bill.

IV. ILLUSTRATION FOR VOLTAGE REGULATION

Peak value in the graph are said to be the power saver values.

CRISP INPUT -80 VOLT; CRISP OUT PUT -175VOLT

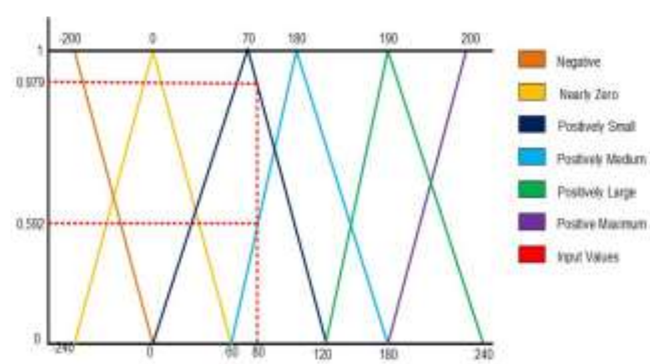

Fig 3 Membership value for single tube light

Table 2 Membership values for the Fuzzy Sets

FUZZY SETS	INPUT SETS	OUTPUT SETS	OUTPUT COMPONENT
Negative	0	-200	0
Nearly zero	0	0	0
Positive Small	0.979	70	68.53
Positive Medium	0.592	180	106.56
Positive large	0	190	0
Positive Maximum	0	200	0

When the crisp input value is 80 volt we get the output value as 175 volt, by this we reduce voltage fluctuation and we can minimize the electricity bill.

V. CONCLUSION

In this paper the design of a fuzzy logic controller was discussed. By this method we can reduce our electric bill and the requirement of current will be reduced for our day to day life. Despite the highly non-linear nature of the system, the transient and steady state performance with the fuzzy controller are seen to be quite satisfactory.

REFERENCES

[1]. A. Ansari and D. M. Deshpande, "Investigation of performance of 3-phase asnchronous machine under voltage unbalance," Journal of Theoretical and applied information Technology, Vol. 16, no.1, pp. 21-26.
[2]. de Silvia, Intelligent control-fuzzy logic applications, CRC press 1995.
[3]. Hadad Kevork and Geza Joos, "A fast algorithm for voltage unbalance compensation and regulation in faulted distribution systems," Proceeding of the IEEE Conference on Applied Power Electronics and Exposition, pp. 963-969, 1998.
[4]. L. Moran, P. Werlinger, J. Dixon and R. Wallace, "A series active power filter which compensates current harmonics and voltage unbalance simultaneously," Proceeding of the IEEE Conference on Power Electronics Specialists, pp. 222-227, 1995.
[5]. Von Jouanne and B. Banerjee, "Assessment of voltage unbalance," IEEE Trans. Vol. 16, no. 4, pp. 782-790, 2001.