Novel Fuzzy Voltage Stabilizer

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Abstract

This paper presents a method of realising a fuzzy logic controller (FLC) for AVR (Automatic Voltage Regulator) system using a personal computer. The FLC is based on simple linguistic rules and implemented for a 2.5 KVA synchronous machine. FAM rules were generated using common sense and intuition. This study shows that a prototype FAM systems can be developed rather quickly for many control problems.

1.0 Introduction

A synchronous generator is normally equipped with an automatic voltage regulator (AVR), which is responsible for keeping the output voltage constant under normal operating conditions at various load levels. It is utmost important that the AVR of the synchronous generator to have a high efficiency and fast response. Until now, the analog proportional-integral-derivative (PID) controller is generally employed for the AVR due to its simplicity and low cost. In this controller, however, it is necessary to adjust the gains of the PID controller in the field. Furthermore, it is not responsive enough to the change of its gains when the operating status is varied [1].

The availability of inexpensive microprocessors has provided a shift for the conventional method toward sophisticated digital controls[1]. Microprocessor based control system has a great deal of flexibility and also allows easy implementation of sophisticated control algorithm such as those of self-tuned PID regulators [2]. However, in view of their large computational requirements and software complexity, the second method was also found to be inappropriate in which the degree of improvement obtained needs to be examined carefully.

In recent years, fuzzy theory has emerged as a powerful tool in various control system applications. Researchers are starting to use fuzzy control in various power systems application areas [3-5]. The application of fuzzy logic control techniques appears to be very useful whenever a well-defined control objectives cannot be specified or the system to be controlled is a very complex one. Under traditional laws of logic, something either belongs to a set or does not, thereby leaving no room for ambiguities. Answers to questions are often "maybe" instead of "yes" or "no". Terms such as warm, cool, partly cloudy, and partly sunny are often used to discuss various weather phenomena [6]. Contrary to traditional logic, where boundaries are rigid, fuzzy logic not tolerates, but is based on the looseness of boundaries.

In this paper, a novel approach for stabilising the synchronous machine using FLC is discussed. The fuzzy logic controller alogorithm is based on simple linguistic rules and was implemented for a 2.5kVA synchronous machine

2.0 Experimental Description.

The general block diagram for this experiment is shown in Figure 1. The prime mover for the synchronous generator is a 3.6 HP DC motor. The motor rotates at the generator rated speed of 1500rpm. The generator output line voltage will be controlled by the field circuit resided in the generator and the variation of the voltages to the field circuit will be supplied by the field exciter circuit that is connected to the computer via digital-to-analogue converter (DAC). The voltage produced by the generator will be sensed by the voltage sensor circuit connected to the output of the generator and this signal will be fed back to the computer via analogue-to digital converter (ADC) to be analysed by the FLC.

Figure 2 shows the experimental steps taken in this experiment. The experiments was carried out in the Power Laboratory in Institut Teknologi MARA. Initially, the ADC/DAC interface will be initialised and start receiving input signal from voltage sensor circuit at 400 samples per second. At first there is no load

connected to the generator output, the voltage received by the ADC card will be 5 volt. This will be processed by the fuzzy engine which will produce an output via the DAC interface to control generator output voltage. The resulting outputs from the FLC at this stage will be zero.

2.1 Fuzzy Logic Controller

In the AVR system being discussed, there are two fuzzy state variables and one control variable. The two fuzzy variables are the error and the rate of voltage change (del-volt). The error is the difference between a predetermined set voltage (220V) and the actual voltage; it can be either positive or negative. This error is positive if the actual voltage is higher than the set voltage and negative if the actual voltage is less than the set voltage. The rate of change of (del-volt) measures the slope of the voltage changes. It is positive if the voltage is rising and negative if the voltage is falling

The fuzzy quantization made up of seven linguistic variables *i.e.* VL: Very Low, LOW: Low, ML: Medium Low, MED: Medium, MH: Medium High, HIGH: High VH: Very High. The fuzzy membership functions as shown in Figures 3, 4 and 5. The fuzzy rules designed for this system is as shown in Table 1.

3.0 Results and Discussion

For the no load condition as shown in Figure 6, the output voltage of the generator was raised to 220 volt from zero. The time taken for the generator voltage to reach 220 volt was measured to be approximately 1 sec. Once the set point voltage of 220 volt is reached, the generator output voltage will be maintain at the set value if there is no load variation.

In Figure 7, it can be seen that after 11 sec of voltage stabilization at the set point value of 220 volt, 0.14 load was connected to the generator output. This reduced the set point voltage of 0.2 volt or 6 volt when refer to 220 volt scale. Automatically FLC will then raised back the voltage to its set point value of 220 volt in 2 sec. Figure 8 shows voltage stabilization after 16 sec, the generator output was connected with 0.27 load. The output voltage reduced 0.4 volt or 17 volt when refer to 220 volt scale. The over period for the FLC to raise back to its set value of 220 volt was 1.5 sec.

3.0 Conclusions

From this experiment, it can be seen that the FLC managed to control the generator's output voltage successfully at its predetermined set value. The control procedure actuated by the FLC was very accurate and fast. This experiment has demonstrated the flexiibility and high potential of FLC in electrical power engineering which can be extended easily to other areas of applications.

References

[1] P.I. Lin and C. Ellsworth, " Design and Implementation of a PC-based Universal Fuzzy Logic Controller System", IEEE Industrial Automation And Control, &(6) Purdue University, Fort Wayne, Indiana, Feb. 1995.

[2] S.Funabiki and A. Hitsumoto, " Automatic Voltage Regulation of a Synchoronous Generator with pole Assignment Self Tunning Regulator", IEEE Transaction on Energy conversion, 9(1), Dept of Electrical and Electronic Engineering, Okayama, 700, Sept.1991.

[3] M. Jamshidi, N. Vadiee and T.J.Ross, " the Fuzzy Logic and Control (Software and Hardware Application)", Prentice hall International, 2, Page: 1-107, Englewood Cliffs, New Jersey, 1993.

[4] P.I. Lin and M.Rashid " A PC-Based Measurement and Control System for DC Motors", Conference Record of 1990 IEEE Industry Application Society Annual Meeting, pp 1829-1834.

[5] M. Jamshidi, N. Vadiee< T.J. Ross, " Fuzzy Logic and Control< Software and Hardware Applications", Vol. 2, 1993, pp. 73-80.

[6] J. Maires and Y.S. Sherif, "Applications of Fuzzy set Theory", Computer, April 1988, pp 83-92.

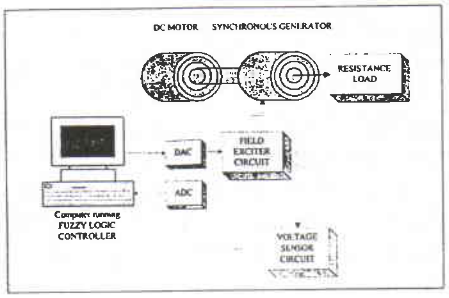


Figure 1: General block diagram for the experiment.

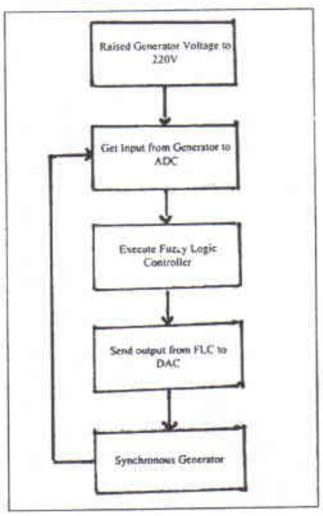


Figure 2: Experimental steps taken in this experiment.

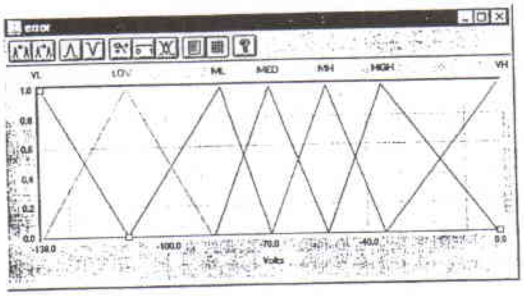


Figure 3: Fuzzy Input Variable "error".

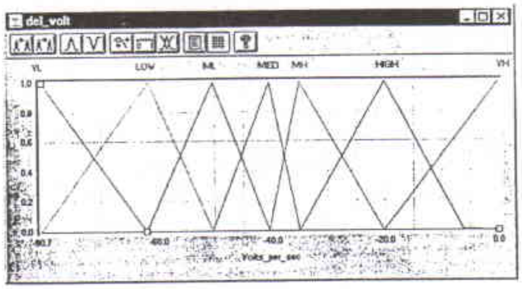


Figure 4: Fuzzy Input Variable "del-volt".

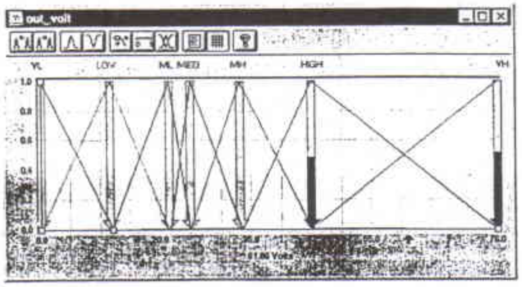
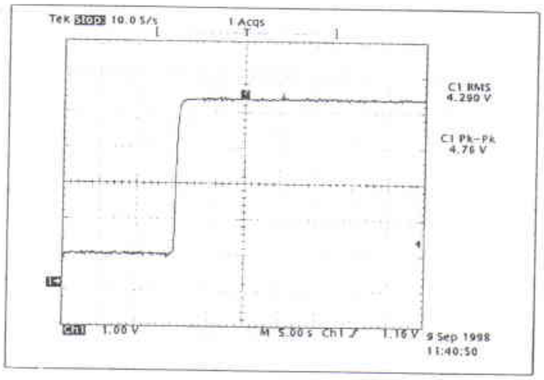


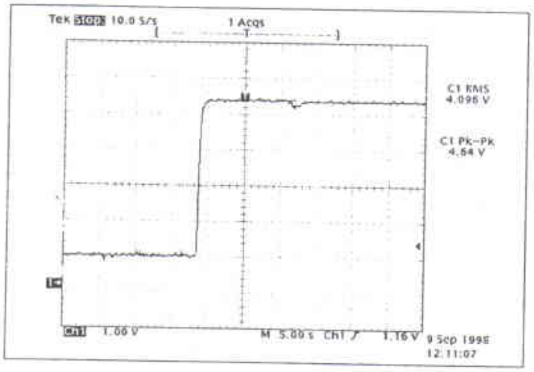
Figure 5: Fuzzy Output Variable "out-volt".



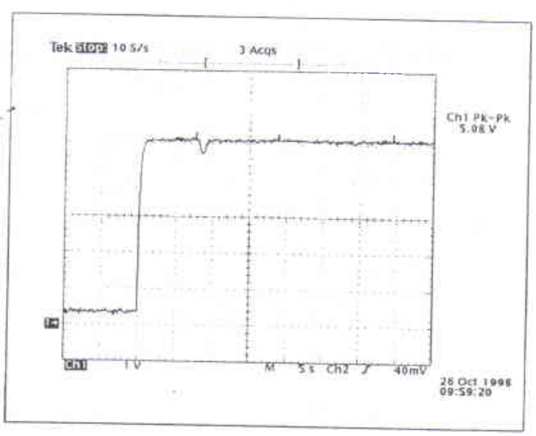
Figuer 6: Response from the FLC for No Load.

	Error							
Del-Volt		VL	LOW	ML	MED	MH	HIGH	VH
	VL	VH	HIGH	HIGH	VL	VL	VL	VL
	LOW	HIGH	HIGH	MH	MED	MED	LOW	LOW
	ML	ML	ML	ML	MED	ML	ML	ML
	MED	MED	MED	MED	MED	MED	MED	MED
	MH	MH	MH	MH	MH	MH	LOW	LOW
	HIGH	HIGH	HIGH	HIGH	HIGH	HIGH	LOW	VL
	VH	VH	VH	VH	VH	VH	LOW	VL

Table 1: FLC Rules Base.



Figuer 7: Response from the FLC for 0.14 Load.



Figuer 8: Response from the FLC for 0.27 Load.