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A REVIEW: STABILITY ENHANCEMENT OF POWER SYSTEM USING FUZZY LOGIC CONTROLLER PSS

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ABSTRACT

This paper present an overview of fuzzy logic control based on published literature, concerned the stability of the electric power system and considerable effort has been directed to the development control system process. This review work on fuzzy logic elaborates the scope of fuzzy logic implementation in process control applications to enhancements the efficiency of the electrical power system stability.

KEYWORDS: Power System Stabilizer, Fuzzy logic Controller, Automatic Voltage Regulator, Multi machine infinite bus, Excitation System.

INTRODUCTION

The concept of fuzzy set was introduced by Prof. Lofti Zadeh in 1965. Since then, the theory has been successfully implemented in various engineering applications, and developed to address inaccuracy and uncertainty which usually exist in engineering problems. Fuzzy logic attempts to systematically and mathematically emulate human reasoning and decision making. It provides an intuitive way to implement control systems, decision making and diagnostic systems in various branches of industry [1]. Fuzzy controllers were developed to imitate the performance of human expert operators by encoding their knowledge in the form of linguistic rules [2]. They provide a complementary alternative to the conventional analytical control methodology. So the human experience and knowledge can be applied to design of the controller by using fuzzy logic, depended on rule-based and the rules of the system are written in natural language [3]. Generally conventional system modeling techniques suggest to construct a model by using the available input-output data based upon empirical or physical knowledge about the system; which lead to the determination of a set of mathematical equations. This kind of approaches is effective only when the system is relatively simple and mathematically well-defined. Beside that most of the real-world problems in controlling do not obey such simple, idealized, and subjective mathematical rules. Fuzzy Logic is a problem-solving control system methodology which can be implemented in hardware, software, or a combination of both. It provides a simple way to arrive at a definite conclusion based upon vague, ambiguous, imprecise, noisy, or missing input information.

SYSTEM MODELING

The Mathematical Models needed for small signal analysis ofSynchronous Machines, Excitation System and lead-lag power system stabilizer are briefly reviewed. The Guidelines for the selection of Power System Stabilizer parameters are also presented.Most PSS used in electric power system employ the liner control theory approach based on a linear model of a fixed configuration of the power system and thus tuned at a certain operating condition. Such fixed parameter PSS, called conventional PSS (CPSS), is widely used in power systems, it often does not provide satisfactory results over a wide range of operating conditions [4].In conventional control, the amount of control is determined in relation to a number of data inputs using a set of equations to express the entire control process. The parameters of CPSS are determined based on a linearized model of the power system around a nominal operating point where they can provided good performance. Because power systems are highly nonlinear systems, with configurations and parameters that change with time, the CPSS design based on the linearized model of the power systems cannot guarantee its performance in a practical operating environment [5].

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To improve the performance of CPSS, numerous techniques have been proposed for their design, such us using intelligent optimization methods (genetic algorithms, neural networks, fuzzy and many other nonlinear control techniques). Hens, expressing human experience in the form of a mathematical formula are a very difficult task, if not an impossible one [6].

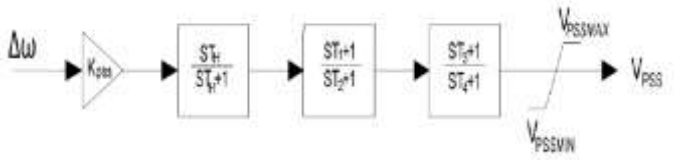

Figure.1 Block diagram of the conventional power system stabilizer.

FUZZY LOGIC CONTROLLER

Zahah introduced his fuzzy set theory; due to that, he observed conventional computer was unable to handling data similar to human idea. In fact, digital computer dealing with binary reasoning, hence fuzzy logic method builds to allow conventional computers to get reason in ways similar to the human, to solve mismatchbetween computers and machines. It proposes deriving solutions to problems that are not possible to construct with exact mathematical models [6][7]. Fuzzy control systems are rule based systems in which a set of fuzzy rules represents a control decision mechanism to adjust the effects of certain causes coming from the system. The structure of the FLC resembles that of a knowledge based controller except that the FLC utilizes the principles of the fuzzy set theory in its data representation and its logic. The basic configuration of the FLC can be simply represented in four parts, as shown in figure-2 [8].

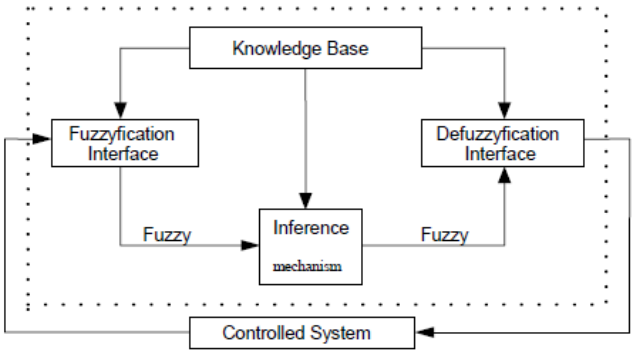

Figure 2. Schematic diagram of the FLC building blocks

Fuzzification module – the functions of which are first, to read, measure, and scale the control variable (speed, acceleration…) and, second, to transform the measured numerical values to the corresponding linguistic .Fuzzy logic can be seen as an extension of ordinary logic, where the main difference is that we use fuzzy sets for the membership of a variable; the membership function may be triangular, trapezoidal, Gaussian or any other shape.
Knowledge base - this includes the definitions of the fuzzy membership functions defined for each control variables and the necessary rules that specify the control goals using linguistic variables;
Inference mechanism – it should be capable of simulating human decision making and influencing the control actions based on fuzzy logic;
Defuzzification module – which converts the inferred decision from the linguistic variables back the numerical values.

PROPOSED CONTROLLER

The conventional control techniques utilize mathematical models for controlling the process. Some heuristics do not fit into mathematical framework, which compelled the modern control system to use soft computing techniques for improving the efficiency and efficacy of the process to be controlled. A Fuzzy Logic is a kind of a state variable controller governed by a family of rule and a fuzzy inference 0.mechanism. The fuzzy logic control algorithm reflects the mechanism of control implemented by people, without using a mathematical model the controlled object, and without an analytical description of the control algorithm. So it emerged as a powerful tool and is starting to be used in various power system applications. There are four possible forms for construction of

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a fuzzy logic control system based on input-output relations. A FLC can be in the form of a single-input-single-output (SISO), double-input-single-output (DISO), multi-input-single-output (MISO)system, or multi-input-multi-output (MIMO) system [9].In any practical system, one of most common ways of designing a fuzzy controller is through "fuzzy rule-based systems". The concept of FLC is to utilize the qualitative knowledge of a system to design a practical controller. A typical feedback control system with direct fuzzy controller is shown in Figure-3.

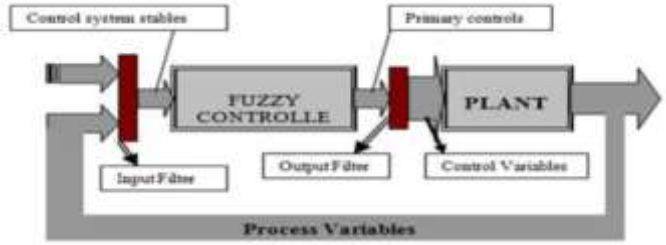

Figure.3 Fuzzy controller with feedback system

On the other hand, fuzzy control focuses on gaining intuitive understanding for better control of the process, and this information is then loaded directly into fuzzy controller. The performance objectives and the design constraints usually involve the stability, rise time, overshoot, settling time and steady state error of process controllers. Researchers showing; a growing interest in artificial intelligent (FL) to design new controllers, because of its ability to effectively implement nonlinear control without much complexity. Metwally and Malik [11] describe a paper on fuzzy logic power system stabilizer using speed and power output variations as the controller input variables. Hiyama [12] obtained the required information i.e. acceleration, speed deviation and phase deviation of generator from measured real power signal. Juan et al. [13] compares the fuzzy logic based and rule base power system stabilizer. Also Moodley et al. [14] investigates the effect of FLPSS in a multimachine environment. Ferreira et al. [15] proposed a fuzzy logic PSS including a fuzzy PI controller to improve steady state behavior of a system .The PI controller as proposed uses only speed deviation as input and uses triangular membership functions with only small number of rules. Lim [16] proposed a new fuzzy logic control scheme using one input signal which is the linear combination of three signals, i.e. signal, its derivative and its integral. Fuzzy logic is applied to in order to improve the power system stability Eltahir&Bahar [17]. The comparison of fuzzy logic with conventional proportional integral controller is made and the superiority of fuzzy logic method is quoted in the study. A methodology for designing and tuning the scaling gains of fuzzy logic controller was discussed and the new concept of fuzzy transfer function was invented to connect these gains of the well-tuned conventional fuzzy logic controller. Furthermore Eltahir&Bahar [18] also presents a new approach to design of a robust controller for the auxiliary control loop of a static VAR stabilizer using fuzzy logic control concepts using the least number of rules for stabilization of a synchronous generator is presented. The performance of fuzzy stabilizer is compared with a conventional stabilizer of a variety of transient disturbances, highlighting the effectiveness of the stabilizer in improving significant damping to the system oscillations the relationship between the scaling gains and performance can be deduced to produce the comparative tuning algorithm, which can tune the scaling gains to their optimum by less trial and error.

Results demonstrated that the proposed control scheme performs well and strongly control the power system under different loading conditions, disturbances and system parameter variations. The proposed controller is robust and more suitable for damping of low frequency oscillation and more effective in improving dynamic stability and voltage profile than the conventional systems.

CONCLUSION AND FUTURE SCOPE

This paper presented an overview of fuzzy logic method applied to solve the power system stabilizers problems. Results of the different case studies were taken in this work show that the fuzzy logic is a great deal of research for tackling non-linear complex process control systems. According to the efforts of these researchers, fuzzy logic is most robust and systematic approach for controlling process, and has been an active research topic in automation and control theory since the work of Mamdani proposed to deal with the system control problems which are not easy to be modeled, based on the fuzzy sets theory.

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