APPLICATION OF FUZZY LOGIC FOR POWER SYSTEM

Meena Gaurkar[1], Chandrakala Gowder [2]

[1] PG Scholar, Electrical Engineering Department, Shri Sai College of Engg & Tech, Bhadravati, Maharashtra, India
[2] Assistant Professor, Electrical Engineering Department, Shri Sai College of Engg & Tech, Bhadravati, Maharashtra, India

ABSTRACT

The basic idea behind this approach was to incorporate the "experience" of a human process operator in the design of the controller. From a set of linguistic rules which describe the operator's control strategy a control algorithm is constructed where the words are defined as fuzzy sets. The main advantages of this approach seem to be the possibility of implementing "rule of the thumb" experience, intuition, heuristics and the fact that it does not need a model of the process. This new approach is receiving more and more attention, not only in test cases but also in real industrial applications. An often remarked disadvantage ot the method, however, seems to be the lack of appropriate tools for analysis of the controllers performance, such as stability, optimality, etc.

The paper presented an application of a multi-criteria fuzzy-logic-based technique to power system like transformer protection, filtering techniques, speed control of motors, transmission line protection. The approach in terms of fuzzy-set procedures was proved to be effective in implementing a simple fuzzy procedure to solve a problem that requires more complex algorithms when approached in a deterministic way. The technique is proved to be fast, accurate and robust and would perform accurately for various system conditions.

Keyword: - *Fuzzy logic controller, transformer protection.*

1. INTRODUCTION

Fuzzy-logic uses a set of rules to define its behavior. The rules define the expected conditions and issue an output using IF-THEN statements. These rules replace formulas. They must cover all situations that may occur but they don't have to be written for every possible combination. Each rule takes the inputs and determines its appropriate output. All of the outputs from the individual rules are combined into one term called the logical sum. The output interfaces with the output device of the system. The inputs are then read again and the cycle starts again for continuous control. This process is described by the block diagram in Fig. 1. The process uses a collection of fuzzy membership functions. Crisp values are first transformed into fuzzy values to be able to use them to apply rules formulated by linguistic expressions.

Then, the fuzzy system transforms the linguistic conclusion back to a crisp value. These steps are described as follows:

1. Fuzzification: Crisp input values are converted to degrees of memberships, and match them with the conditions of the rules to determine how well the condition of each rule matches that particular input.
2. Fuzzy-rule base: The collection of rules is called a rule base. The truth-value for the premise of each logic rule is computed and applied to the conclusion part of each rule. This results one fuzzy set to be assigned to each output variable for each rule.
3. Inference system: Inference from a set of fuzzy rules involves fuzzification of the conditions of the rules, then propagating the membership values of the conditions to the outcomes of the rules.
4. Defuzzification: Fuzzy concepts involved in the conclusion of the fuzzy-rule set are translated back into object terms before they can be used in practice. To do this a membership functions must be defined.

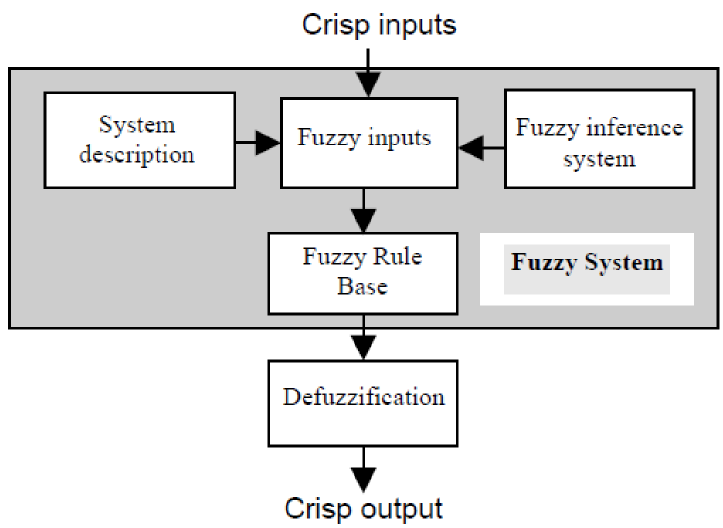

Fig.1:- Fuzzy control system.

2. FUZZY LOGIC APPLICATIONS IN POWER SYSTEM

Author presents the new Fuzzy Logic Controller (FLC) [1] for on-load tap change control for distribution transformers. The model of a transformer with its tap changing mechanism is given first. Next, the FLC is presented in details. The proposed algorithm is optimized from the numerical point of view and proved to be implementable on contemporary Programmed Logic Controllers (PLCs). The simulation results are included that compare the proposed control algorithm with the classical inverse-time controller and prove the efficiency of the new solution.

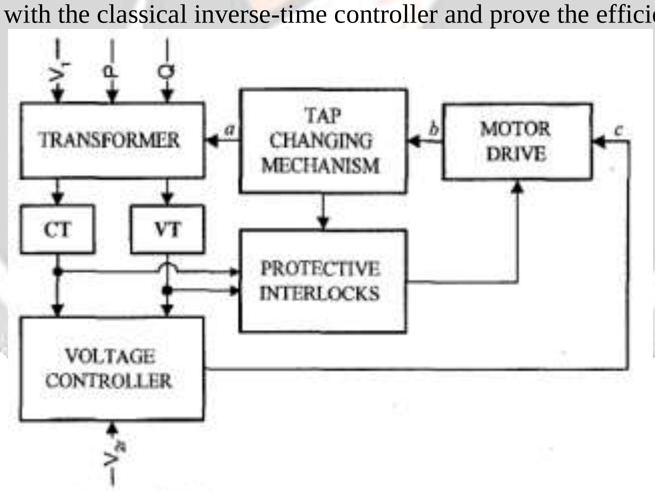

Fig. 2:- The simplified block diagram of the considered system of a distribution transformer with its tap changing mechanism.

Author introduces the use of a fuzzy logic controlled synchronous motor for reactive power compensation [2]. The fuzzy logic controlled synchronous motor can give a very fast response to the reactive power required by the load. Therefore, the over or under compensation and time delay are eliminated in this system. It is concluded that the reactive power compensation system with a fuzzy logic controlled synchronous motor is reliable, sensitive, economical, faster and more efficient than another one with capacitor groups.

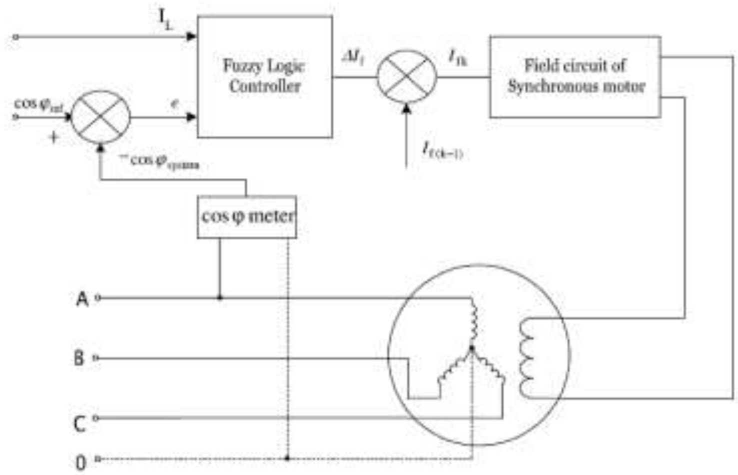

Fig.3:- A basic block diagram of fuzzy logic based compensation system [2].

Fast tripping and consequent single-pole auto-reclosure of the faulted phase for single-phase earth faults is extensively used in long line applications. Traditional phase selection techniques can suffer some drawbacks due to their dependency on varying system and fault conditions. However, with the advent of fuzzy-logic techniques and their ability to map complex and non-linear power system configurations provide a very attractive solution to accurate and fast phase selection procedure.

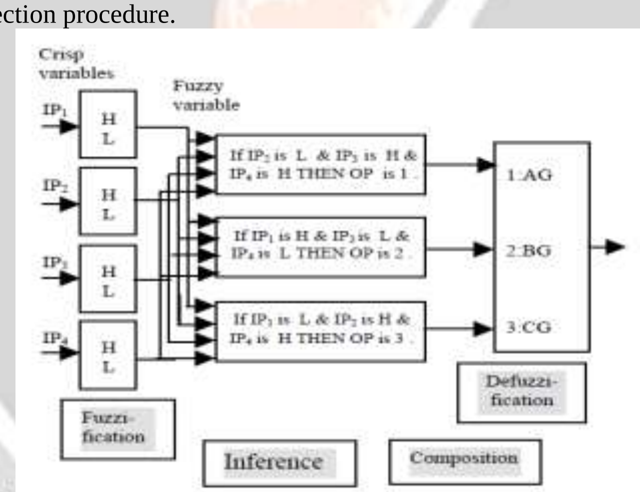

Fig.4:- Fuzzy block diagram of the phase selector.

One of the author presents [3] a new approach to real-time phase selection in power transmission systems using fuzzy-logic-based multi-criteria approach. Only the three line currents are utilized to detect the faulted phase. Also demonstrates the multi-criteria algorithm that is based on fuzzy sets for the decision making part of the scheme. Computer simulations have been conducted using EMTP programs. Results proved that the correct detection is achieved in less than half a cycle and that computational burden is simpler than the recently postulated phase selection techniques, and this approach can be used as an effective tool for high speed digital relaying.

Authors presents a novel approach for differential protection of power transformers [4]. This method uses wavelet transform (WT) and adaptive network-based fuzzy inference system (ANFIS) to discriminate internal faults from inrush currents. The proposed method has been designed based on the differences between amplitudes of wavelet transform coefficients in a specific frequency band generated by faults and inrush currents. The performance of this algorithm is demonstrated by simulation of different faults and switching conditions on a power transformer using PSCAD/EMTDC software. Also the proposed algorithm is tested off-line using data collected from a prototype laboratory three-phase power transformer.

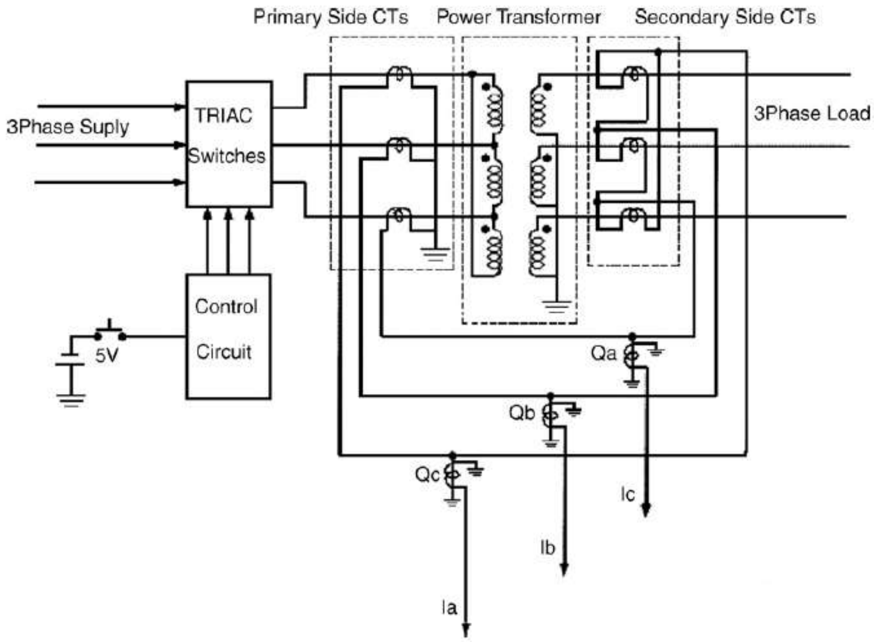

Fig.5:- Experimental setup for differential current data collection [4].

Authors presents fuzzy logic control of Doubly Fed Induction Generator (DFIG) wind turbine [5] in a sample power system. DFIG consists of a common induction generator with slip ring and a partial scale power electronic converter. Fuzzy logic controller is applied to rotor side converter for active power control and voltage regulation of wind turbine. Wind turbine and its control unit are described in details. All power system components are simulated in PSCAD/EMTDC software and for fuzzy control, using a user defined block, this software is linked to MATLAB. For studying the performance of controller, different abnormal conditions are applied even the worst case. Simulation results prove the excellent performance of fuzzy control unit as improving power quality and stability of wind turbine.

A new loss-of-excitation protection based on fuzzy set theory has been presented [6]. It makes use of conventional concepts of loss-of-excitation protection in synchronous generators (i.e., the behavior of internal voltage and apparent impedance trajectory).

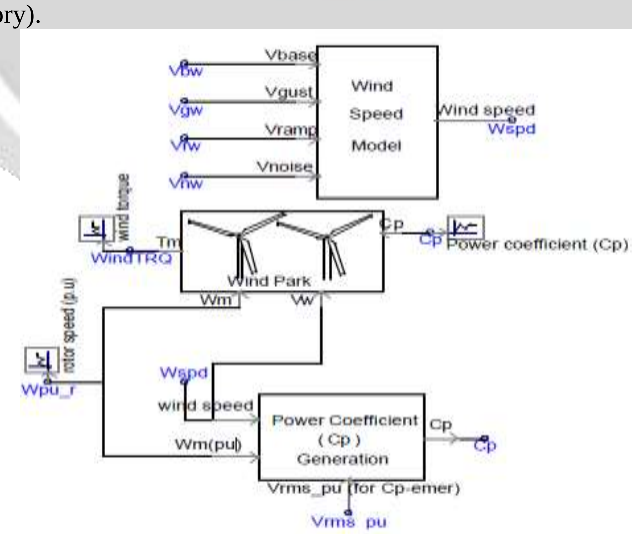

Fig.6:- Wind speed and power coefficient modeled in PSCAD/EMTDC [5].

Instead of crisp values, a fuzzy inference mechanism is applied. To show the effectiveness of the proposed technique, comparisons are made with traditional protection methods by considering different generators sizes. The protection scheme proposed displays a secure and effective high-speed loss-of-excitation detection during power swings. Furthermore, the performance of the proposed method was not affected by generator parameters.

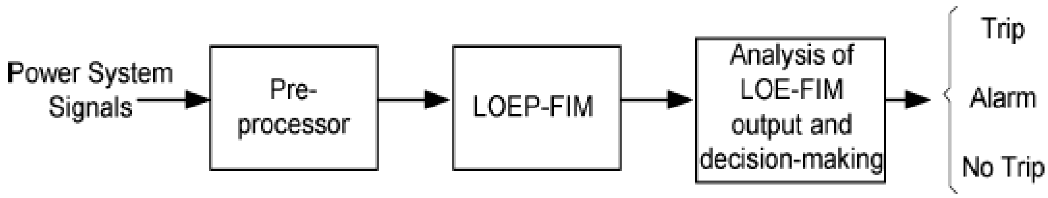

Fig.7:- General scheme of LOEP-FIM [6].

Dynamic Voltage Restorer (DVR) [7] is used in power distribution system to protect sensitive loads in voltage disturbances. The performance of DVR is related to the adopted configuration and control strategy used for inverters. An asymmetrical voltage-source inverter controlled with fuzzy logic method based on hysteresis controller, is used to improve operation of DVR to compensate voltage sag/swell. Simulation results using MATLAB/ Simulink are presented to demonstrate the feasibility and the practicality of the proposed novel Dynamic Voltage Restorer topology. Total Harmonic Distortion (THD) is calculated.

Active filters are widely used in power system for reactive power compensation and voltage / current harmonic elimination. Harmonic contents of the source current has been calculated and compared for the different cases to demonstrate the influence of harmonic extraction circuit on the harmonic compensation characteristic of the shunt active power filter.

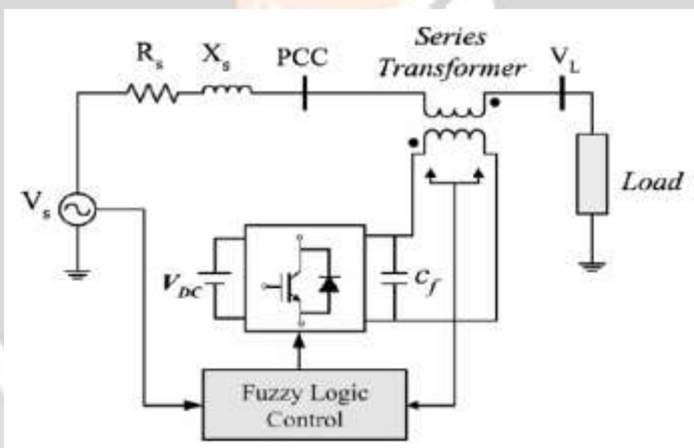

Fig.8:- Typical DVR circuit topology (single-phase representation) [7].

A fuzzy logic controlled [8], three-phase shunt active filter is used to improve power quality by compensating current harmonics which is required by a nonlinear load. The merit of fuzzy control is that it is based on defined linguistic rules and does not require any mathematical model of the system unlike the other traditional controller.

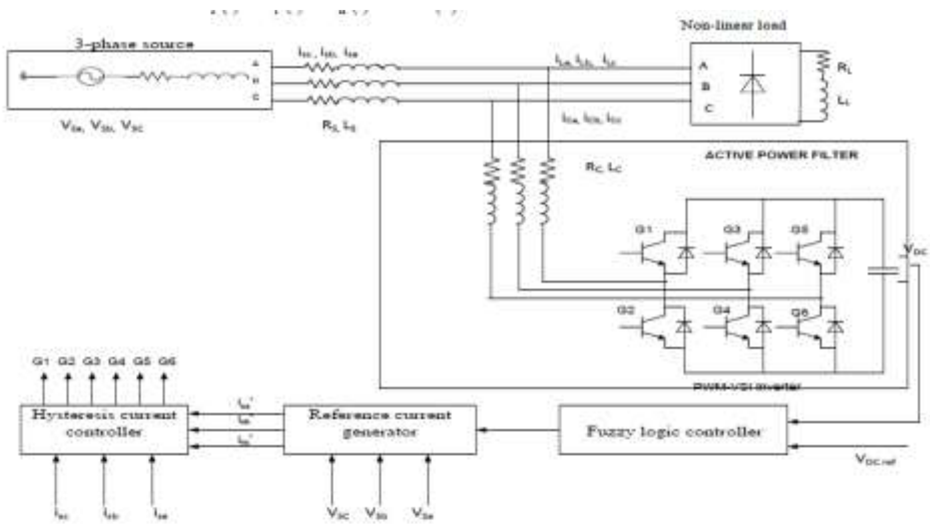

Fig.9:-. Block diagram of Shunt Active Power Filter with proposed FLC [8].

3. CONCLUSION

The paper presented an application of a multi-criteria fuzzy-logic-based technique to power system like transformer protection, filtering techniques, speed control of motors, transmission line protection. The approach in terms of fuzzy-set procedures was proved to be effective in implementing a simple fuzzy procedure to solve a problem that requires more complex algorithms when approached in a deterministic way. The technique is proved to be fast, accurate and robust and would perform accurately for various system conditions. In conclusion, fuzzy-based systems have the following inherent advantages:

1. They can approximate any function to any degree of precision, and they require a smaller number of rules than crisp rule-based function approximates.
2. Well-crafted fuzzy rules are easy to understand and they can be added to improve performance and execution speed.
3. Each rule corresponds to a wide range of input values, and they are evaluated in parallel (order does not matter).

On the other hand care must be taken into consideration when a change in MF (rule), a corresponding change must be performed in the MF (rule).

4. REFERNCES

[1] Kasztenny, B., Rosolowski, E., Izykowski, J., Saha, M. M., & Hillstrom, B. (1998). Fuzzy logic controller for on-load transformer tap changer. IEEE Transactions on Power Delivery, 13(1), 164-170.

[2] Colak, I., Bayindir, R., & Bay, Ö. F. (2003). Reactive power compensation using a fuzzy logic controlled synchronous motor. Energy Conversion and Management, 44(13), 2189-2204.

[3] Youssef, O. A. (2004). A novel fuzzy-logic-based phase selection technique for power system relaying. Electric Power Systems Research, 68(3), 175-184.

[4] Monsef, H., & Lotfifard, S. (2007). Internal fault current identification based on wavelet transform in power transformers. Electric power systems research, 77(12), 1637-1645.

[5] Karimi-Davijani, H., Sheikholeslami, A., Livani, H., & Karimi-Davijani, M. (2009). Fuzzy logic control of doubly fed induction generator wind turbine. World Applied Sciences Journal, 6(4), 499-508.

[6] de Morais, A. P., Cardoso, G., & Mariotto, L. (2010). An innovative loss-of-excitation protection based on the fuzzy inference mechanism. IEEE Transactions on Power Delivery, 25(4), 2197-2204.

[7] Ezoji, H., Sheikholeslami, A., Rezanezhad, M., & Livani, H. (2010). A new control method for dynamic voltage restorer with asymmetrical inverter legs based on fuzzy logic controller. Simulation Modelling Practice and Theory, 18(6), 806-819

[8] Agrawal, S., & Bhuria, V. (2013). Shunt active power filter for harmonic mitigation by using fuzzy logic controller. International Journal of Advanced Research in Computer Engineering & Technology (IJARCET), 2(6), 1950-1954.