Reactive Power Compensation in Transmission Line using Fuzzy Control Method: A Survey

Yojna Saratkar[1], Arun Pachori[2]

Abstract

If we discuss about the capacitor allocation strategy, then there are several factors like time, allocation size, distribution feeder comes in our mind. Static VAR Compensator (SVC) is a shunt type FACTS device which is used in power system primarily for the purpose of voltage and reactive power control. In this paper we survey and analyzes fuzzy controller, how it is utilize in terms of reactive power compensation. We also discuss about the applicability and feasibility.

Keywords

FACTS, Fuzzy Controller, Reactive Power, VAR.

1. Introduction

After studying several research works in the field of Reactive Power Compensation, the demand for controllable reactive power source has gone up mainly for efficient and reliable operation of ac electric power system [1]. VAR compensators should be controlled to provide rapid and continuous reactive power supports during static and dynamic power system operating conditions [2]. Flexible AC Transmission systems (FACTS) controllers are emerging as an effective alternative to increases or enhance power transfer capability and stability of the network by redistributing the line flow and regulating the bus voltages. Static VAR compensator (SVC) and Thyristor controlled series compensator (TCSC) are some of the commonly used FACTS controllers [3]. Power System Stability is the ability of the system to regain its original operating conditions after a disturbance to the system [4]. Power system transient stability analysis is considered with large disturbances like sudden change in load, generation or transmission system configuration due to fault or switching [5]. It is very important to stable the voltage supply, so that the performance is increases and because of the stability the loss is reduces.

Yojna Saratkar, M.Tech Scholar, Jabalpur Engineering College Jabalpur, M.P.
Arun Pachori,Assistant Professor**,** Jabalpur Engineering College Jabalpur, M.P.

The main elements for generation and absorption of reactive power are transmission line, transformers and alternators. The transmission line distributed parameters throughout the line, on light loads or at no loads become predominant and consequently the line supplies charging VAR.

The Static VAR Compensator (SVC) is a shunt device of the Flexible AC Transmission Systems (FACTS) family using power electronics to control power flow and improve transient stability on power grids[6] [7]. The SVC regulates voltage at its terminals by controlling the amount of reactive power injected into or absorbed from the power system [6]. When system voltage is low, the SVC generates reactive power (SVC capacitive). When system voltage is high, it absorbs reactive power (SVC inductive)[6].

The remaining of this paper is organized as follows. In Section 2 we discuss about fuzzy control method. Related work in section 3.In section 4 we discuss about analysis. The conclusions are given in Section 5. Finally references are given.

2. Fuzzy Control Method

A fuzzy control system is a control system based on fuzzy logic which is a mathematical system for the analysis of analog input values in terms of logical variables that take on continuous values between 0 and 1, in contrast to classical or digital logic, which operates on discrete values of either 1 or 0.

Fuzzy controllers are very simple conceptually. They consist of an input stage, a processing stage, and an output stage. The input stage maps sensor or other inputs, such as switches, thumbwheels, and so on, to the appropriate membership functions and truth values. The processing stage invokes each appropriate rule and generates a result for each, then combines the results of the rules. Finally, the output stage converts the combined result back into a specific control output value.

The most common shape of membership functions is triangular, although trapezoidal and bell curves are also used, but the shape is generally less important than the number of curves and their placement. From three to seven curves are generally appropriate to cover the required range of an input value, or the "universe of discourse" in fuzzy jargon.

It is a collection of logic rules in the form of IF-THEN statements, where the IF part is called the "antecedent" and the THEN part is called the "consequent". Typical fuzzy control systems have dozens of rules.

Consider a rule for an even number generation:
IF ("value is divisible by 2") THEN ("number is even"). Because of the logical applicability the uses of fuzzy controller in a very wide area including power system.

The below Figure1 shows a microcontroller chip with a simple feedback controller:

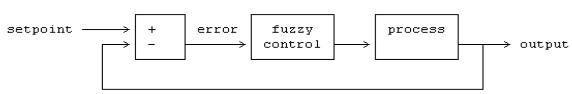

Figure 1: microcontroller chip with a simple feedback controller

A fuzzy set is defined for the input error variable "e", and the derived change in error, "delta", as well as the "output", as follows:
LP: large positive
SP: small positive
ZE: zero
SN: small negative
LN: large negative

3. Related Work

In 2009, N.Karpagam et al. [4] discusses about Static VAR Compensator (SVC) which is a shunt type FACTS device which is used in power system primarily for the purpose of voltage and reactive power control. Authors developed a fuzzy logic based supplementary controller for Static VAR Compensator (SVC) which is used for damping the rotor angle oscillations and to improve the transient stability of the power system. Generator speed and the electrical power are chosen as input signals for the Fuzzy Logic Controller (FLC). The effectiveness and feasibility of the proposed control is demonstrated with Single Machine Infinite Bus (SMIB) system and multi machine system (WSCC System) which shows improvement over the use of a fixed parameter controller.

In 2010, Karuppanan P et al. [8]describes the proportional integral (PI), proportional integral derivative (PID) and fuzzy logic controller (FLC) based three phase shunt active power line conditioners (APLC) for the power-quality improvement such as reactive power and harmonic current compensation generated due to nonlinear loads. PI, PID controller requires precise linear mathematical model and FLC needs linguistic description of the system. According to the authors the controller is capable of controlling dc capacitor voltage and generating reference source currents. Hysteresis current controller is used for current control in PWM voltage source inverter. Extensive simulation studies under transient and steady states are conducted, the simulation result analysis reveal that the APLC performs perfectly in conjunction with PI, PID and FLC.

In 2012, S.Kavitha et al. [9] aims at designing and implementing a fuzzy controller for Multiple Input Single Output temperature process. Temperature control of water in the tank is achieved by varying current to the heating rod and inlet flow rate by a fuzzy controller. According to the author the system consists of a tank, reservoir, variable speed pump, temperature sensor placed inside a heating tank containing the heating rod, voltage controlled current source and computer. Water is pumped into the tank from reservoir and RTD measures the current temperature. The signal from the temperature sensor is sent to the DAQ interfaced to the computer. LabVIEW software is used to acquire the input signal and send the output signal that is determined by the control algorithm. Fuzzy logic controller is designed in LabVIEW. Based on the set point temperature, the controller sets the appropriate current to the heating rod. If the required temperature is less than that sensed by the temperature sensor, the flow rate of water into the tank is controlled by a variable speed pump. While conventional controllers are analytically described by a set of equations, the FLC is described by a knowledge-based algorithm. Thus this system is highly efficient in both heating and reducing the temperature of the tank. A fuzzy logic controller gives faster response, is more reliable and recovers quickly from system upsets. It also works well to uncertainties in the process variables and it does not require mathematical modelling.

In 2012, R.krishna sampath et al. [3] discuss about STATCOM (Synchronous Static Compensator) based on voltage source converter (VSC) is used for voltage regulation in transmission and distribution system.

The STATCOM can rapidly supply dynamic VARs required during system faults for voltage support. Strict requirements of STATCOM losses and total system loss penalty preclude the use of PWM (Pulse-Width Modulation) for VSC based STATCOM applications. They propose and develop an “emergency PWM” strategy to prevent over-currents (and trips) in the VSC during and after single line to ground system faults, LLLG faults and to ensure that the STATCOM supplies required reactive power. System performance during a nonlinear load connected without any fault is also considered. The Simulation results are shown for a 48-pulse VSC based ± 100 MVAR STATCOM connected to a 2-bus power strategy to prevent VSC over-currents and to supply required reactive power under line to ground system faults.

In 2012, Ashish Choubey et al. [10] discusses to enhance power supply reliability for the user terminals in the case of the distribution system to avoid interference by the fault again, rapidly complete the automatic identification, positioning, automatic fault isolation, network reconfiguration until the resumption of supply of non-fault section, a microprocessor-based relay protection device has developed. As the fault component theory is widely used in microcomputer protection, and fault component exists in the network of fault component, it is necessary to build up the fault component network when short circuit fault emerging and to draw the current and voltage component phasor diagram at fault point. In order to understand microcomputer protection based on the symmetrical component principle, they obtained the sequence current and sequence voltage according to the concept of symmetrical component.

In 2012,D.Raaga Leela et al. [11]an EP and PSO based optimization algorithms have been proposed for solving optimal power flow problems with multiple objective functions. These algorithms take into consideration all the equality and inequality constraints. The improvement in system performance is based on reduction in cost of power generation and fuzzy based network security. The proposed algorithms have been compared with the other methods reported in the author’s literature.

In 2012, Arti Pateriya et al. [12] discusses about the growth of complex electrical power networks introduces lack of controllability of active and reactive power flow in energies networks Power flow control in an existing long transmission line, plays an important role in power system area. Their paper employs the shunt connected compensation STATCOM based FACTS devices for the control of voltage and the power flow in long distance transmission line. The proposed device is used in different locations of transmission line and also deals with determination of the optimal location of shunt flexible A.C. transmission line (FACTS) devices for a long transmission line for voltage and power transfer improvement. The results also show the line loading and system initial operating conditions.

In 2013, Shyamal Sen et al. [13] presents a piecewise linear approximation method for solving separable quadratic programming problems by using linear fuzzy goal programming (FGP) methodology. In the proposed approach, the objectives are first described fuzzily by introducing imprecise aspiration level to each of them. The fuzzy goals are then characterized by their associated membership functions for representation of goal achievement in terms of membership values of fuzzy goals. In the model formulation of the problem, the defined membership functions are first transformed into membership goals by assigning the highest membership value (unity) and introducing under-and over-deviational variables to each of them. Then, the membership goals in quadratic form are transformed into linear goals by using piecewise linear approximation method. In the solution process, minimization of under- deviational variables in the goal achievement function under the minsum FGP solution approach is considered.

In 2013, Bijay Baran Pal et al. [14] presents how fuzzy goal programming (FGP) method can be efficiently used modelling and solving power generation and dispatch (PGD) problems in power system operation and planning horizon. Accoring to the authors objectives of a problem involved with optimal power flow computation are considered fuzzy in nature in an uncertain decision environment. In the solution process, minsum FGP methodology is addressed to minimize the deviations from the aspired goal levels and thereby to reach a satisfactory decision on the basis of needs and desires of the decision maker (DM) in the decision making context.

4. Analysis

After studding and observing several literatures in the direction of our paper then we analyse the applicability of fuzzy controller in several fields. There are several works in the direction of Reactive Power Compensation, but there is still need of improvement. There are several works in the direction of deregulation of power system, fuzzy goal programming and controlled active and reactive flow control. There are some analyses where we still lacking are following:

1) Need of Automated System
2) Cost Optimization
3) Energy Consumption
4) Power Utilization
5) Improvement of Stability

5. Conclusion

In this paper we survey several aspects of Reactive Power Compensation and fuzzy controller. We discuss the related literature with the advantages and achieved results. This paper provides a proper direction about the future enhancement and goal planning. We also discuss about the fuzzy controller, how it relates in different area, so that we have a clear idea of their workability and future applicability in different fields.

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