

Power Quality Improvement of Three-phase four-wire DSTATCOM with Fuzzy logic Controller

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Abstract— The topology and control of three-phase 4-wire DSTATCOM consisting of a operating flexibility in the voltage or current control mode. In the voltage control DSTATCOM topology includes three single-phase voltage source converters connected in parallel. The proposed DSTATCOM provides the voltage regulation of power factor correction along with harmonics elimination, load balancing and neutral current compensation in 3-phase 4-wire system. Fuzzy logic techniques are primarily applied since quick control strategy is needed and imprecise and qualitative definition of action plans are available. While designing an optimal fuzzy controller, one has to look for two primary activities. There are find optimal membership functions for control and action variable, find an optimal set of rules between control and action variable.

Keywords— Power Quality, DSTATCOM, Fuzzy Controller, Neutral Current Compensation.

I. INTRODUCTION

Power quality issues are gaining significant attention due to the increase in the number of sensitive loads. Many of these loads use equipment that is sensitive to distortion supply voltage. DSTATCOM is a voltage source converter based power electronic device. The load compensation using a DSTATCOM one of the device. The load compensation using a DSTATCOM one of the major considerations is the generation of the reference compensator currents [4]. The power quality problems in the three phase four-wire distribution systems are different type of non-linear loads. These power quality problems include high reactive power burden, harmonic currents and load unbalance [13]. In this paper a converter based on the parallel connection two-leg three-phase converter for both parallel and series compensation [8] three phase four wire distribution power systems are widely used in office buildings, commercial complexes, manufacturing facilities and so on.[10]. Owing to the widely application of power converters in the industry products, power pollution has been serious problem in the distribution system. The power pollution due to large non-linear loads low power factor, low efficiency of power system, voltage distortion and losses in the transmission and distribution lines[11]. The three phase four-wire distribution power systems have the problems of harmonic pollution, load unbalance and over load of neutral conductor. A zigzag transformer is applied to suppress the neutral current, however this method can solve the problem of neutral conductor but it is can't solve the harmonic problem [1]. Three phase four wire distribution systems ever used to supply single-phase low voltage loads. The typical loads may be computer loads, lighting ballasts [13].

II.DSTATCOM IN POWER DISTRIBUTION SYSTEMS

A DSTATCOM is a capable of compensating either bus voltage or line current. If it operates in a voltage control mode [4] three phase 4-wireDSTATCOM is used for reactive power and harmonics currents compensation along with load balancing and neutral current compensation. [13]the voltage source converter consists of four insulated-gate bipolar transistors (IGBT's) three ac inductors and two dc capacitors. The unity power sensed as feedback signals. The load currents in 3-phase are converted into the d_{qo} frame. Using park's transformation as

$$\begin{bmatrix} i_{Ld} \\ i_{Lq} \\ i_{L0} \end{bmatrix} = \frac{2}{3} \begin{bmatrix} \cos\theta & -\sin\theta & \frac{1}{2} \\ \cos\left(\theta - \frac{2\pi}{3}\right) & -\sin\left(\theta - \frac{2\pi}{3}\right) & \frac{1}{2} \\ \cos\left(\theta + \frac{2\pi}{3}\right) & \sin\left(\theta + \frac{2\pi}{3}\right) & \frac{1}{2} \end{bmatrix} \begin{bmatrix} i_{la} \\ i_{lb} \\ i_{lc} \end{bmatrix}$$

A three-phase PLL (phase locked loop) is used to synchronise these signals with the PCC voltage. These d-q current components are then passed through low pass filters to extract the dc components of I_d and I_q .

The error between the reference dc capacitor voltage and the sensed dc bus voltage of DSTATCOM is given to a PI (proportional-integral) controller and its output voltage is considered as the loss component of the current and is added to the dc component of I_d .

$$i_{loss(n)} = i_{loss(n-1)} + K_{pd}(V_{dc(n)} - V_{dc(n-1)}) + K_{id} V_{dc(n)}$$

where, $V_{dc(n)} - V_{dc(n-1)}$ is the error between the Reference (V_{dc^*}) and sensed (V_{dc}) dc voltage at the n^{th} sampling instant. K_{pd} and K_{id} are the proportional and integral gains of the dc bus voltage PI controller. The error between the difference of the dc bus capacitors voltages and its reference zero value is given to another PI controller and the output (I_{equal}) is also added to the dc component of i_d . The reference source current is therefore as,

$$I_d^* = I_{ddc} + I_{loss} + I_{equal}$$

Similarly, a second PI controller is used to regulate the PCC voltage. The amplitude of PCC voltage and its reference value are fed to a PI controller and the output of the PI controller is added to the dc component of because this is estimated as the quadrature component of current for regulating the ac voltage.

$$i_{qr(n)} = i_{qr(n-1)} + k_{pq}(V_{te(n)} - V_{te(n-1)}) + k_{iq}V_{te(n)}$$

where, $V_{te(n)} = V_{s^*} - V_{s(n)}$ denotes the error between reference (V_{s^*}) and sensed $V_s(n)$ terminal voltage

amplitudes at the n th sampling instant. K_{pq} and K_{iq} are the proportional and the integral gains of the dc bus voltage PJ controller. The reference supply quadrature axis current is as,

$$i_{q^*} = i_{qdc} + i_{qr}$$

The control strategy is to regulate the PCC voltage, elimination harmonics in load currents and the load balancing. The resultant d-q-o currents are again converted into reference source currents using the reverse Park's transformation. The reference currents in two phases are used for the control of the H-bridge VSC. The sensed and reference supply current are compared in the two phases before comparing with a triangular carrier signal to generate the gating signals for four switches for power factor correction of the load. The FPCC voltage PI controller is set as zero in the control algorithm of DSTATCOM.

A distribution static compensator is a voltage source converter based power electronic device. Usually this device is supported by short – term energy stored in a dc-capacitor when a DSTATCOM is associated with a particular load, it can inject compensating current so that the total demand meets the specifications for utility connection. For load compensation using a DSTATCOM, one of the major considerations is the generation of the reference compensator currents.

A DSTATCOM can be realized using a VSC and dc storage capacitor. One of the requirements of a DSTATCOM in a three-phase four-wire distribution system is that is capable of injecting three un-balanced and distorted currents in to the AC system to cancel voltage or current unbalance.

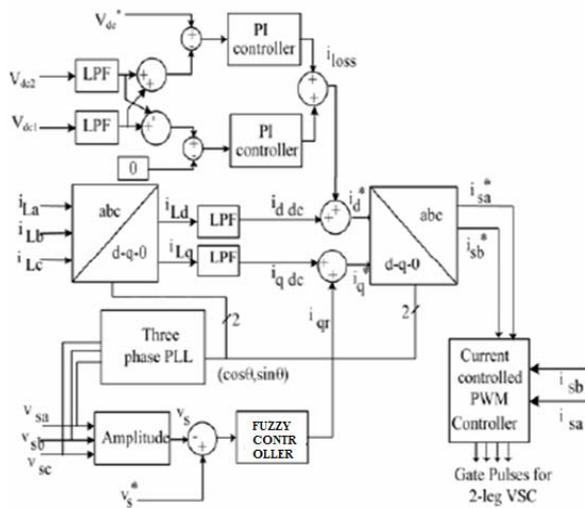


Figure1: Control algorithm for the operation of fuzzy logic controller based on DSTATCOM in three- phase four-wire system.

III. CONTROL THE VSC OF DSTATCOM

In this paper a converter based on the parallel connection of basic building blocks constitutes by tow-leg three phase converters for both parallel and series compensation is desired [8]. There are many control algorithms available for the generation of reference source currents for the control of voltage source converter of DSTATCOM for the phase four wire system in the literature. The instantaneous reactive power theory (p-q) theory, synchronous reference frame theory power balance theory [13]. In the three phase four wire distribution system mainly due to the different type of nonlinear loads, distribution system. The power

quality problems including high reactive power burden, harmonic currents, load unbalance and excessive neutral current. The power quality problems in the literature survey and the group of controllers used in the distribution system is known as the custom power devices. The custom power devices including the distribution static compensator, dynamic voltage restorer and unified power quality conditioner and are used for compensating the power quality problems in the current, voltage. The DSTATCOM is developed and installed in the distribution system for power quality improvement. Some of the topologies of three phase four wire DSTATCOM for the mitigation of neutral current along with the power quality improvement of the supply current are voltage source converter and using the zigzag transformer. In this investigation a new topology of DSTATCOM is proposed with a transformer is used compensations for a three phase four wire system. The DSTATCOM can be control the voltage regulation on a power distribution system, the single phase inverters are used along with star/delta transformer.

IV. FUZZY CONTROLLER

In the above two cases, Gas have been suitably used. Figure shows typical membership functions for a variable (control or action) having three choices low, medium, and high. Since the maximum membership function value of these choices is always one, the abscissa marked by X_i is usually chosen by the user. These abscissa can be posed to find these variables for minimizing or maximizing a control strategy such as time of variable operation, product quality, and others[6]. Although this rule base may not be the optimal one, GA can process a population of such rule bases and finally find the optimal rule base. Once the rows present in the rule base are determined from the string user, defined fixed membership functions can be used to simulate the underlying process. The objective function can be evaluated and the usual single point cross over and a mutation operator (one allele mutating to one of three other alleles) can be used with this coding. GA can find the optimal number of rules to solve the problem. If one wants to use binary strings instead of ternary strings and two bits are used to represent each of four operations, a total of 30 bits is necessary to represent a rule base[7]. This kind of technique has been used to design fuzzy logic controller for mobile robot navigation among dynamic obstacles. Both optimum membership function determination and optimal rule base tasks achieved simultaneously by using a concatenation of two coding mentioned above.

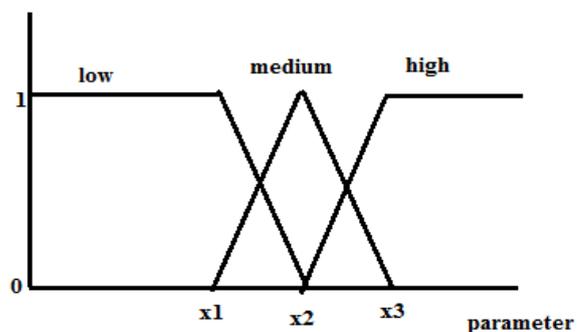


Figure2: Fuzzy membership function and typical variables used for optimal design

Fuzzy controllers are used to control consumer products, 2274

such as washing machines, video cameras, and rice cookers, as well as industrial processes, such as cement kilns, underground trains, and robots. Fuzzy control is a control method based on fuzzy logic. Just as fuzzy logic can be described simply as "computing with words rather than numbers, fuzzy control can be described simply as "control with sentences rather than equations". A fuzzy controller can include empirical rules, and that is especially useful in operator controlled plants.

The objective here is to identify and explain the various design choices for engineers. In a rule based controller the control strategy is stored in a more or less natural language. The control strategy is isolated in a rule base opposed to an equation based description. A rule based controller is easy to understand and easy to maintain for a non-specialist end-user.

A measurable disturbance is being compensated. It requires a good model, but if a mathematical model is difficult or expensive to obtain, a fuzzy model may be useful. a controller and the fuzzy compensator, the process and the feedback loop are omitted for clarity. The scheme, disregarding the disturbance in-put, can be viewed as a collaboration of linear and nonlinear control actions; the controller C may be a linear PID controller, while the fuzzy controller F is a supplementary nonlinear.

Fuzzy logic has two different meanings. In a narrow sense, fuzzy logic is a logical system, which is an extension of multivalve logic. However, in a wider sense fuzzy logic (FL) is almost synonymous with the theory of fuzzy sets, a theory which relates to classes of objects with unsharp boundaries in which membership is a matter of degree. In this perspective, fuzzy logic in its narrow sense is a branch of fl. Even in its more narrow definition, fuzzy logic differs both in concept and substance from traditional multivalve logical systems.

In fuzzy Logic Toolbox software, fuzzy logic should be interpreted as FL, that is, fuzzy logic in its wide sense. The basic ideas underlying FL are explained very clearly and insightfully in Foundations of Fuzzy Logic. What might be added is that the basic concept underlying FL is that of a linguistic variable, that is, a variable whose values are words rather than numbers. In effect, much of FL may be viewed as a methodology for computing with words rather than numbers. Although words are inherently less precise than numbers, their use is closer to human intuition. Furthermore, computing with words exploits the tolerance for imprecision and thereby lowers the cost of solution.

Another basic concept in FL, which plays a central role in most of its applications, is that of a fuzzy if-then rule or, simply, fuzzy rule. Although rule-based systems have a long history of use in Artificial Intelligence (AI), what is missing in such systems is a mechanism for dealing with fuzzy consequents and fuzzy antecedents. In fuzzy logic, this mechanism is provided by the calculus of fuzzy rules. The calculus of fuzzy rules serves as a basis for what might be called the Fuzzy Dependency and Command Language (FDCL). Although FDCL is not used explicitly in the toolbox, it is effectively one of its principal constituents. In most of the applications of fuzzy logic, a fuzzy logic solution is, in reality, a translation of a human solution into FDCL.

A trend that is growing in visibility relates to the use of fuzzy logic in combination with neuron computing and genetic algorithms. More generally, fuzzy logic, neurocomputing, and genetic algorithms may be viewed as the principal constituents of what might be called soft computing. Unlike the traditional, hard computing, soft computing accommodates the imprecision of the real world.

V. EXPERIMENTAL RESULTS

The performance of distribution static compensation consisting of fuzzy-logic and the use of the T/F for point of common coupling voltage regulation in load balancing of a three-phase four wire system. The load is changed tow-phase load and again to single – phase load at 1.7sec. the voltage at point of common coupling, supply current, load currents, load neutral current, compensator neutral current, dc bus voltage, spilt capacitor voltages.

The dynamic performance of DSTATCOM with voltage regulation & harmonic elimination along with neutral current compensation at 1.1sec, the load is changed to two-phase load and again to single phase load at 1.2 sec. the loads are applied again at 1.3 sec. & 1.4 sec. respectively

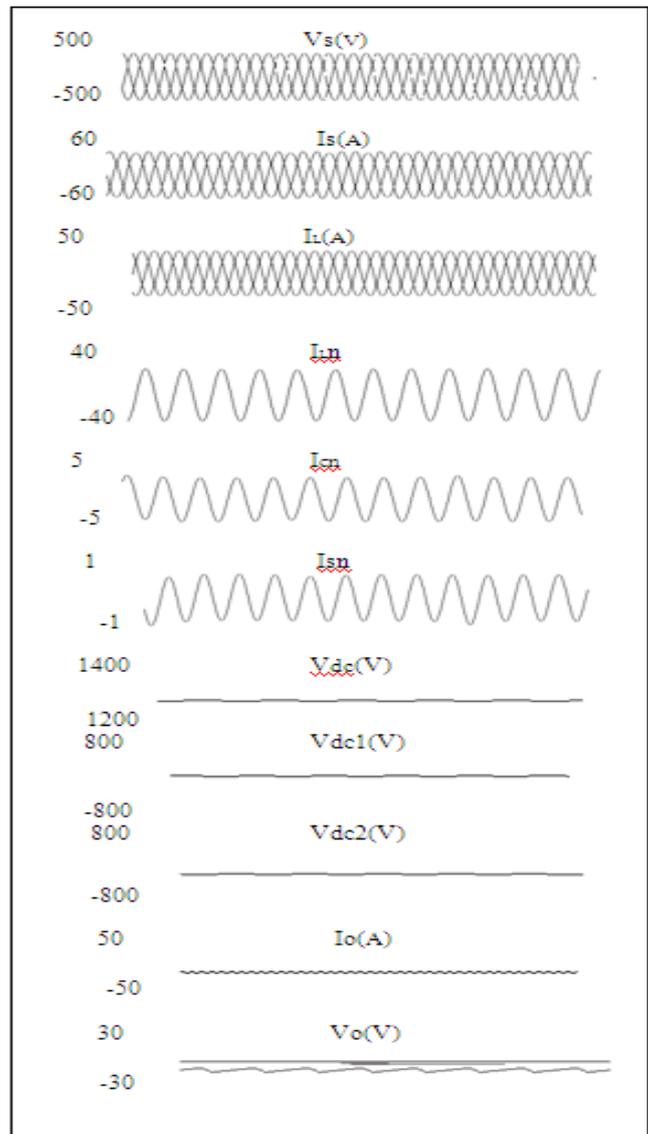


Figure 3: Performance of proposed DSTATCOM for neutral current compensation, load balancing and power factor correction.

VI. CONCLUSION

The performance of a new topology of three-phase four-wire DSTATCOM consisting of fuzzy logic controller has been demonstrated for neutral current compensation along with reactive power compensation harmonic elimination and load balanced. The neutral current and it has been found effective for compensating the zero sequence fundamental and harmonic currents. The voltage regulation and power factor correction modes of operation of the DSTATCOM have been observed.

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