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DESIGN AND IMPLEMENTATION OF NEW DPFC TO CONTROL POWER QUALITY

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ABSTRACT

A new control scheme to improve and maintain the power quality of an electrical power system i.e. distributed power flow controller. Generally, In case of modern power utilities have problems like challenges in growth of electricity in case of non-linear loads in grid connected systems. In this paper, we introduced a new series-shunt type FACTS controller called as distributed power flow controller. This DPFC method is same as the UPFC used to compensate the voltage sag and the current swell. In DPFC, we eliminate the common dc link capacitor and instead of single three phase series converter it has three individual single phase converters. In this paper, the control circuit is designed by using series referral voltages and branch currents. The evaluated values are obtained by using MATLAB/SIMULINK.

Key words: DPFC, Voltage sag and Swell, Power quality.

INTRODUCTION

Because of power demand grows dramatically and extension in transmission and generation is restricted with the rigid environmental constraints and the limited availability of resources. By considering the transmission i.e., the transmission of electrical energy form generating stations to consumer points, the term power quality is used to measure the quality of power and how the system effected by transmission elements. From consumer side, the power quality issue is concentrated about how the transmission line parameters such as voltage, current and other are affected and deviated from their actual values due to occurrence of disturbance. For solving such type of power quality problem in literature point of view the method based on the power electronic based equipment's such as i.e. dynamic voltage regulator is used in both transmission and distribution system[1]. However, most of the issues occurred in distribution and transmission system are deviations in voltage such as sag and swell and harmonics generated in currents due to non-linear loads. For compensating

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these problems compared all other devices the Flexible AC Transmission System provides the efficient work. These are classified as Static compensator, series-shunt controllers. Out of all these methods, in this paper we presenting a new controller under series-shunt controller called a distributed power flow controller[2]. Basically, this device is a combination of one parallel converter in combination with more number of series converters. This device can compensate the problems in parameters of the transmission line.

Working of DPFC

The structure of DPFC system has following modification as compared with UPFC i.e. dc link capacitor is removed and uses as individual converter using 3^{rd} harmonic currents are injected in transmission for active power exchange. The DPFC is a combination of multiple series converters, single parallel converter. The parallel one is considered as STATCOM and the series converters is considered from the concept of DVR. The controlling capacity of the UPFC is back-to-back connection of series and the shunt converters with a DC link, which is used for exchanging the power. To make that the DPFC also having the equal controlling capacity like UPFC, i.e. it doesn't have common dc link capacitor. Therefore, it exchanges the active power through the converter AC terminals. The Distributed Power Flow Controller has the merits over the UPFC, such as: high controlling reliability, more efficiency and least economy.

Control circuit for DPFC

According to Fig. 1 the control strategies of Distributed Power Flow Controller are classified in to mainly three types: i.e. 1) Main controller, 2) DVR controller and 3) Static controller. The central controller is used to control DVR and static controllers by generation of referral signals like series voltages and currents. The main purpose of this series control technique is used to compensate the voltage quality problems by maintain the voltage of capacitor in rated value. This controller is operated based on the reference signals generated by capacitor voltages in both direct and quadrature frame. Generally, these series controllers have first order low pass and third order band pass filters to create natural and 3^{rd} order harmonic currents. A 3^{rd} order harmonic current is inserting into the transmission line to generate suitable active power to DVR converter; it is the main aim to use this control. In a proportional and integral controller output is directly proportional to the summation of proportional of error and integration of the error signal. Proportional controller helps in reducing the steady state error, thus makes the system more stable. Slow response of the over damped system can be made faster with the help of these controllers.

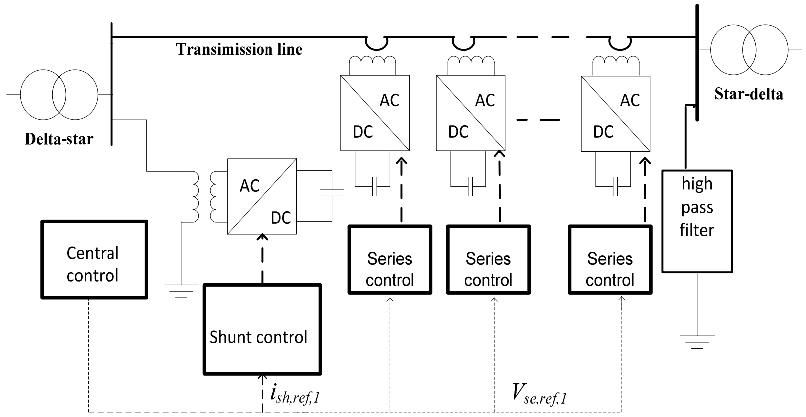

Fig. 1: Control diagram of DPFC

Fuzzy logic controller

Fuzzy control system is a mathematical system, which is completely based on fuzzy logic. Fuzzy controllers, which are directly use the fuzzy rules. Fuzzy rules are conditional statements, gives the relationship among all fuzzy variables. The logic involved in the fuzzy controller[3] can deal with concepts that cannot be expressed as true or false. Fig. 2 shows the Fuzzy Logic Controller block diagram. The fuzzy set is defined by a function that maps objects in a domain of concern to their membership value in the set. Such a function is called membership function and is usually denoted by Greek symbol "µ". Fig. 3 shows the selection of number of inputs and outputs in the form of membership functions in order to design FIS. There are basically two Fuzzification methods namely, Mamdani and Sugeno and generally used Defuzzification methods are: Adaptive integration, Center of area, Center of gravity, Fuzzy clustering Defuzzification, First of maximum, Last of maximum, Mean of maxima, Semi-linear Defuzzification, Centroid method. Basically Defuzzification is the process of converting the fuzzy conclusion into the crisp one and above is the different methods of Defuzzification used.

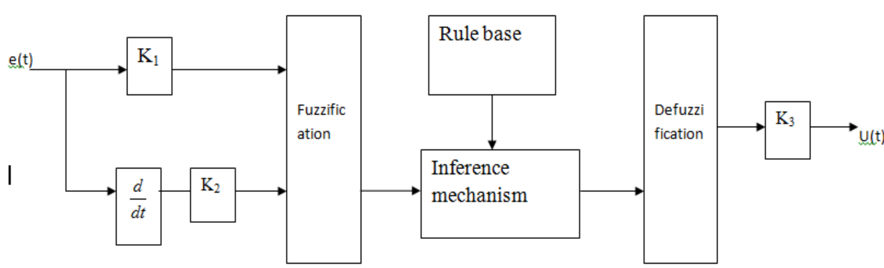

Fig. 2: Fuzzy logic controller block diagram

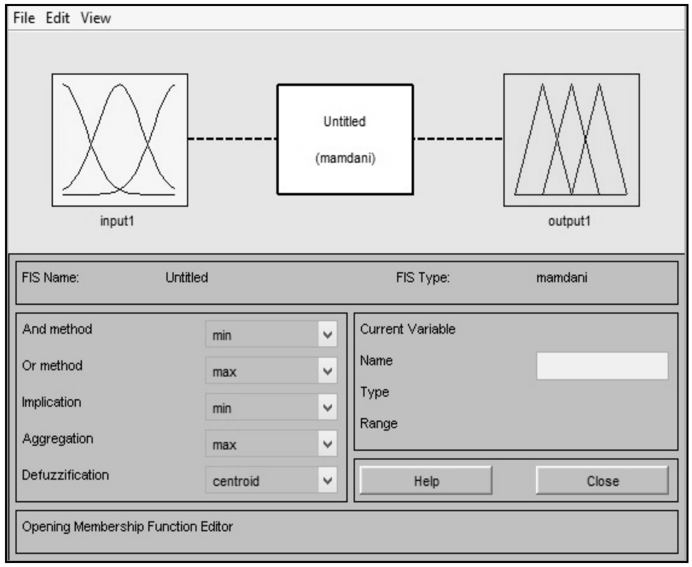

Fig. 3: Input output selection for FIS design

Basic steps of fuzzy inference structure (FIS)

The algorithm of fuzzy rule-based inference consists of four basic steps given as follows: Fuzzy Matching: Calculate the degree to which the input data match the condition of the fuzzy rules. Inference: Calculate the rules conclusion based on its matching degree. Combination: Combine the conclusion inferred by all fuzzy rules into a final conclusion. Defuzzification: For applications that need a crisp output (e.g., in control systems), this step is used to convert a fuzzy conclusion into a crisp one.

Fuzzy rules for developing FIS

Human beings make decisions based on rules. Although, we may not be aware of it, all the decisions we make are all based on computer like if-then statements. if – then fuzzy statements for fuzzy inference structure (FIS) Fuzzy machines always tend to mimic the behavior of man. Fuzzy rules also operate using a series of if-then statements. The fuzzy control rule is based on fuzzy decision-making, which satisfies some input conditions and has an output result. It can work with less precise inputs, doesn't need fast processors, is more robust than other non-linear controllers and Fuzzy controllers have better stability, small overshoot and fast response. Rao et al.[4-18] have published their results on battery materials, power sources, different oxide materials, luminescent materials, polymers, glasses and on different drugs in their earlier studies.

EXPERIMENTAL

In this, we consider a case study such as creating a voltage dip condition by implementing a three phase fault in a single machine system. The experimental diagram is implemented by basic diagram which is shown in Fig. 4. In this system, the fault occur between the times 500 to 1500 m. During this fault time the voltage is goes to sag position as shown in Fig. 5. The voltage magnitude is reduced by 0.65 % of its nominal value during this fault time.

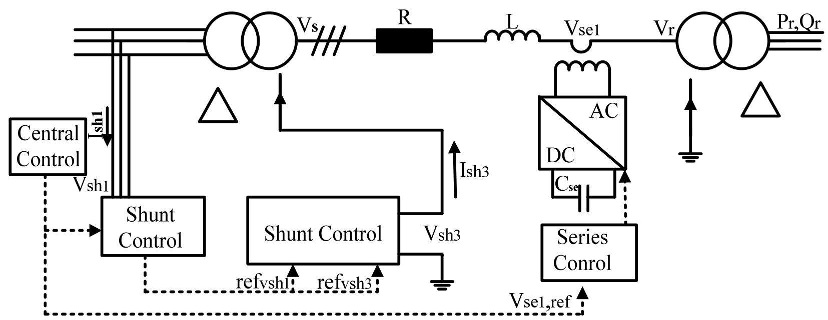

Fig. 4: Structure of DPFC

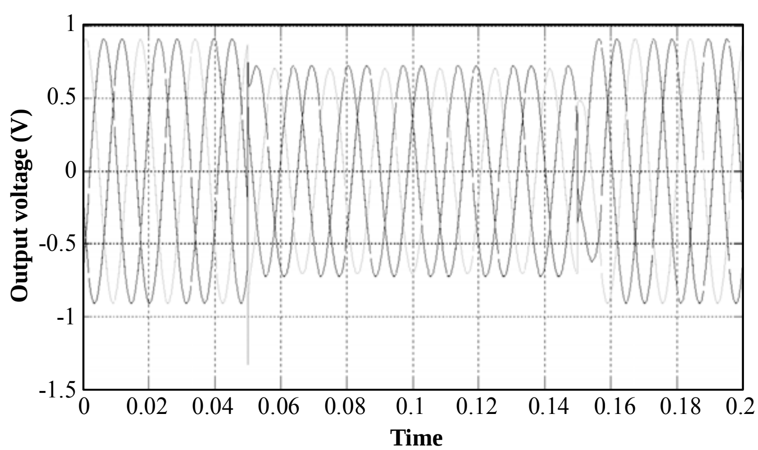

Fig. 5: Output voltage during fault condition

Fig. 6 shows the simulation result for output voltage during fault. In this fault period a sag condition occurs in the output voltage (Fig. 7). During this fault time the load current raises its magnitude around 1.2% per unit as shown in Fig. 8. THD value for a system is 12.36% and it is reduced by using DPFC controller.

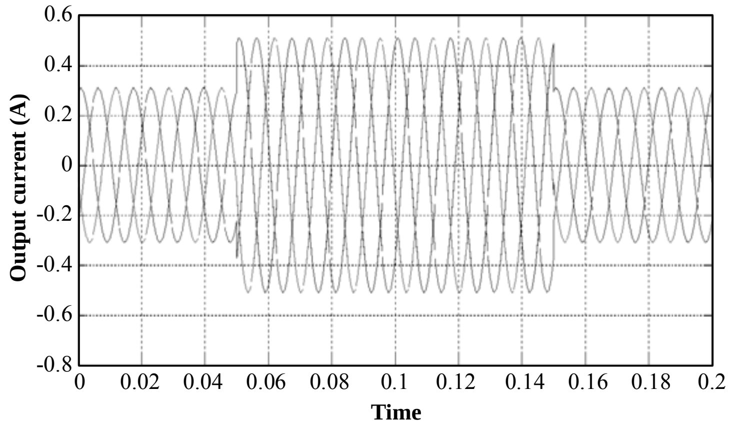

Fig. 6: Output Current during fault condition

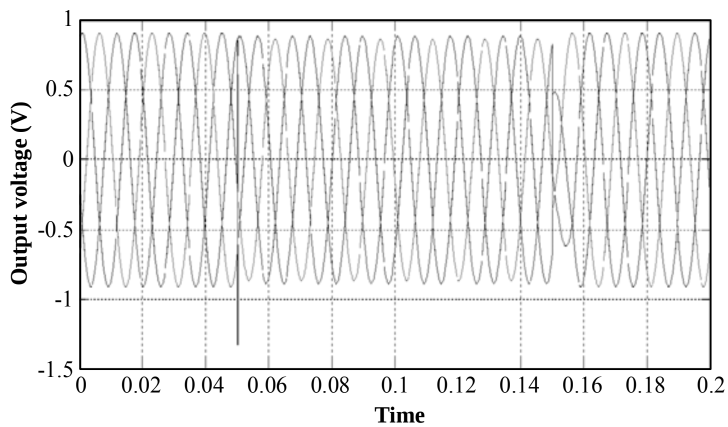

Fig. 7: Output voltage compensated by DPFC controller

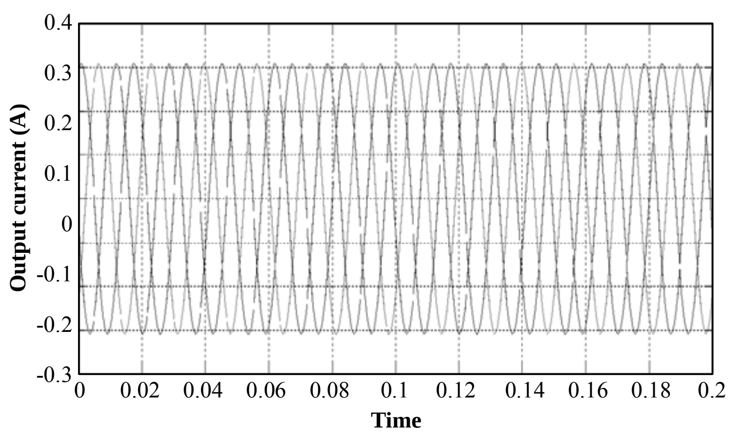

Fig. 8: Compensated output current by DPFC controller

A PI controller based DPFC controller is used for that system and now the THD value is reduced to 3.88%. Now the PI controller is replaced with fuzzy controller the THD value is reduced to 3.65%. THD values for load voltage without DPFC (Fig. 9), load voltage with DPFC using PI controller (Fig. 10) and load with DPFC using fuzzy controller (Fig. 11) are compared and listed in the Table 1.

Table 1: Comparison of THD values

S. No.	Name	THD value
1	Load voltage without DPFC	12.36%
2	Load voltage with DPFC (PI)	3.88%
3	Load voltage with DPFC (Fuzzy)	3.65%

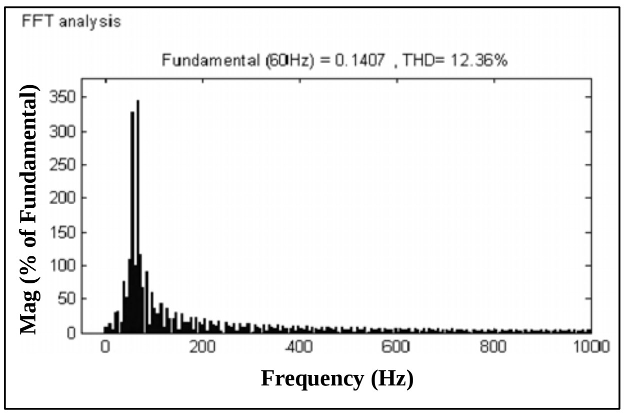

Fig. 9: THD of load voltage without DPFC (pi controller)

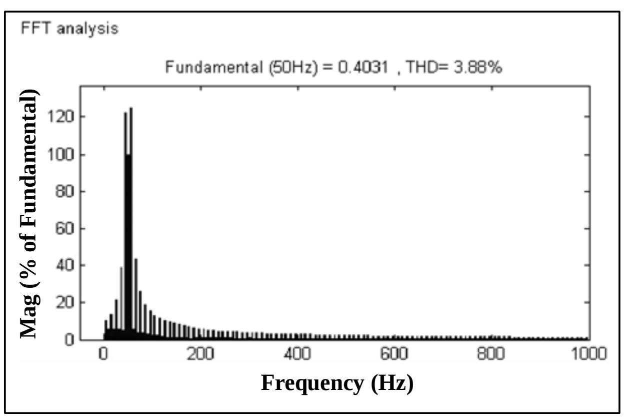

Fig. 10: THD of load voltage with DPFC (pi controller)

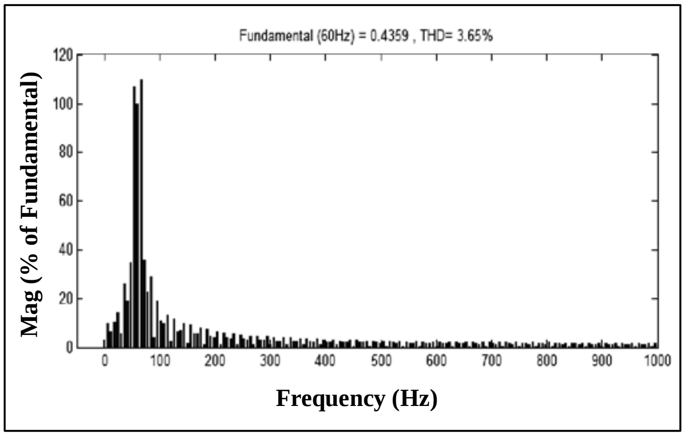

Fig. 11: THD of load voltage with DPFC (fuzzy controller)

CONCLUSION

In this paper, we implemented a new concept for controlling power quality problems by DPFC. The proposed theory of this device approach is mathematically formulated and analyzed for voltage dips and their mitigations for a three phase source with linear load. In this paper, we also proposed a concept of fuzzy logic controller for better controlling action. As compared to all other facts devices the DPFC based Fuzzy has effectively control all power quality problems and with this technique we get the THD as 3.65%.

REFERENCES

1. A. Jamshidi, S. M. Barakati and M. M. Ghahderijani, Int. J. Engg. Tech., **4**, 5 (2012).
2. A. Jamshidi, S. M. Barakati and M. M. Ghahderijani, IEEE (2012).
3. G. A. Kaur, Int. J. Inno. Tech. Exp. Engg., **1**, 1 (2012).
4. M. C. Rao and K. Ramachandra Rao, Int. J. ChemTech Res., **6(7)**, 3931 (2014).
5. Sk. Muntaz Begum, M. C. Rao and R. V. S. S. N. Ravikumar, J. Inorg. Organometa. Poly. Mater., **23(2)**, 350 (2013).
6. M. C. Rao, J. Crys. Growth, **312(19)**, 2799 (2010).
7. M. C. Rao, Optoelect. Adv. Mater., (Rapid Commu.), **5**, 85 (2011).
8. Sk. Muntaz Begum, M. C. Rao and R. V. S. S. N. Ravikumar, J. Mol. Struct., **1006(1)**, 344 (2011).
9. M. C. Rao, Optoelect. Adv. Mater., (Rapid Commu.), **5(5-6)**, 651 (2011).

10. Sk. Muntaz Begum, M. C. Rao and R. V. S. S. N. Ravikumar, Spectrochim. Acta Part A: Mol. Biomol. Spec., **98**, 100 (2012).
11. M. C. Rao, J. Optoelect. Adv. Mater., **13**, 428 (2011).
12. M. C. Rao and O. M. Hussain, Optoelect. Adv. Mater., **13(2-4)**, 1109 (2011).
13. K. Ravindranadh, M. C. Rao and R. V. S. S. N. Ravikumar, Appl. Mag. Reson., **46(1)**, 1 (2015).
14. M. C. Rao, Optoelect. Adv. Mater., (Rapid Commu.), **6**, 511 (2012).
15. M. C. Rao and O. M. Hussain, Eur. Phys. J. Appl. Phys., **48(2)**, 20503 (2009).
16. K. Ravindranadh, M. C. Rao and R. V. S. S. N. Ravikumar, J. Luminesce., **159**, 119 (2015).
17. M. C. Rao and O. M. Hussain, Ind. J. Eng. Mater. Sci., **16**, 335 (2009).
18. M. C. Rao, J. Optoelect. Adv. Mater., **12**, 2433 (2010).

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