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Original Article

A Fuzzy Logic Controller (FLC) and Dynamic Voltage Regulator (DVR) Based Power Quality Improvement In Transmission Line By Using Active Power Filter and Passive Power Filter

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Abstract: *This paper demonstrates with Active Power Filter and Passive Power Filter. It is great specified in Minimizing the voltage and current based harmonics and improvement in the Power factor with the relatively low capacity active power filter. In reconstitute power system, Power Quality is one of the most important Modern eras. The Problems associated with the voltage sags and voltage swells are one of the powerful impacts on the sensitive loads.*

To recover from this problem, Custom Power devices are usually used. One of those devices is Dynamic Voltage Regulator (DVR) and Fuzzy Logic Controller (FLC). The Dynamic Voltage Restorer (DVR), which is one of the most effective in modern custom power devices used in Power Distribution Network and Fuzzy Logic Controller (FLC) control the algorithm DVR is proposed in this paper to control the load terminal voltage during the sag, swell in the voltage at the point of common coupling (PCC). An adaptive fuzzy dividing frequency control method composed of a generalized PI control unit and fuzzy adjustor unit was proposed. In the new control scheme, The PI control unit is used to achieve dividing frequency control method whereas the fuzzy adjustor unit is used to adjust the parameters of the PI control unit to generate better adaptive ability and dynamic response.

The Fuzzification rules are used to generate The Dynamic Voltage Regulator (DVR). This voltage is injected in series for the pulse Width Modulation (PWM) Control and problems associated with Power Quality are not only easy to be calculated and implemented, but also very effective in reducing harmonics.

Keywords: *FLC controller, DVR, PI controller, APF, PPF, PCC, THD*

I. INTRODUCTION

In case to solve the harmonics problem of the grid, the passive power filters (PPF) is often used at the point of common coupling (PCC) conventionally. However, it has many disadvantages like resonance, instability, mistuning, etc . . . . which prevent its execution [5][6]. The use of the active power filter (APF) to mitigate harmonic problems has drawn much attention since the 1970s. APFs seem to be a feasible solution for eliminating harmonic currents and voltages. There are many different methods to mitigate voltage sags and swells, but the use of a custom power device is considered to be the most efficient method, e.g. FACTS for transmission systems which improve the power transfer capabilities and stability margins. There are different types of Custom Power devices used in electrical network to improve power quality problems. One of those devices are Dynamic Voltage Regulator (DVR) and Fuzzy Logic Controller (FLC)

II. DYNAMIC VOLTAGE REGULATOR (DVR)

DVR is widely considered as an effective custom power device in mitigating voltage sags. In addition to voltage sags and swells compensation, DVR can also add other features such as harmonics and Power Factor correction. Compared to the other devices, the DVR is clearly considered to be one of the best economic solutions for its size and capabilities. DVR also known as Static Series Compensator maintains the load voltage at a desired magnitude and phase by compensating the voltage sags/swells and voltage unbalances presented at the point of common coupling [2].

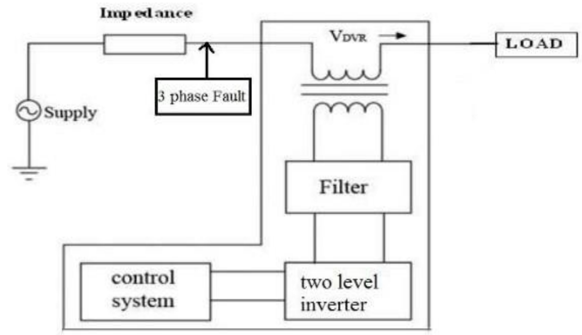

Figure 1: Schematic diagram of a DVR

Basic Configuration of Dynamic Voltage Restorer:

i. An Injection/ Booster transformer.
ii. A Harmonic filter.
iii. Storage Devices.
iv. Voltage Source Converter (VSC).
v. DC charging circuit.
vi. Control and Protection system.

III. FUZZY LOGIC CONTROLLER (FLC)

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 un sharp boundaries in which membership is a matter of degree. In this perspective, fuzzy logic in its narrow sense is a branch of fuzzy logic. Even in its more narrow definition, fuzzy logic differs both in concept and substance from traditional multivalve logical systems [7]. The fuzzy adjustor is used to adjust the parameters of proportional control gain KP* and integral control gain KI* based on the error e and the change of error e. Kp = KP* + ΔKP and KI = KI* + ΔKI .Where KP *and KI* are reference values of the fuzzy- generalized integrator PI controller [3]. In this paper, K P * and KI* are calculated offline based on the Ziegler–Nichols method. In a fuzzy-logic controller, the control action is determined from the evaluation of a set of simple linguistic rules. The development of the rules requires a thorough understanding of the process to be controlled, but it does not require a mathematical model of the system. [8]. The block diagram fuzzy-logic adjustor is shown in figure below.

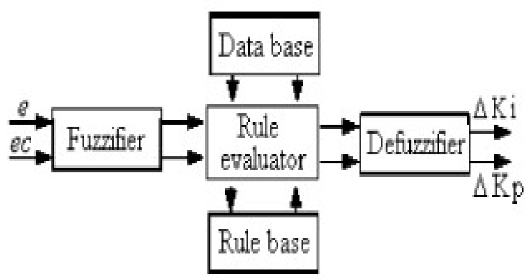

Figure 2: Block Diagram of Fuzzy Logic Controller

In this way, system stability and a fast-dynamic response with small overshoot can be achieved with proper handling of the fuzzy-logic adjustor. Fuzzification converts crisp data into fuzzy sets, making it comfortable with the fuzzy set representation of the state variable in the rule. In the fuzzification process, normalization by reforming a scale transformation is needed at first, which maps the physical values of the state variable into a normalized universe of discourse. [7]. The error e and change of error e_e are used as numerical variables from the real system. To convert these numerical variables into linguistic variables, the following seven fuzzy levels or sets are chosen as: negative big (NB), negative medium (NM), negative small (NS), zero (ZE), and positive small (PS), positive medium (PM), and positive big (PB). [5]. To ensure the sensitivity an robustness of the controller, the membership function of the fuzzy sets for e (k), e_e(K) and ΔKI in this paper are acquired from the ranges of e (k), and ΔKI, which are obtained from project and the equation's (1) and (2). And the membership functions are shown in Figure respectively.

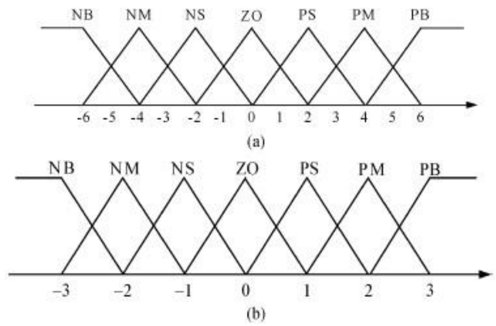

Figure 3: Membership Functions of the Fuzzy Variable

- Membership function of e (k), $e_e(K)$
- Membership function of ΔKP and ΔKI

The core of fuzzy control is the fuzzy control rule, which is obtained mainly from the intuitive feeling for and experience of the process. The fuzzy control rule design involves defining rules that relate the input variables to the output model properties. For designing the control rule base for tuning ΔKP and ΔKI, the following important factors have been taken in to account [6].

1. For large values of e, a large ΔKP is required, and for small values of e, a small ΔKP is required.
2. For e. (ek)> 0, a large is required, and for e. (ek) < 0, a small ΔKP is required.
3. For large values of e and ek, ΔKI is set to zero, which can avoid control saturation.
4. For small values of e, ΔKI is effective, and ΔKI is larger when e is smaller, which is better to decrease the steady-state error. So the tuning rules of ΔKP and ΔKI can be obtained from the below tables. [9].

Table 1: Adjusting rule of the ΔKP parameter

ΔKp		e_c						
		NB	NM	NS	0	PS	PM	PB
	NB	PB	PB	NB	PM	PS	PS	0
	NM	PB	PB	NM	PM	PS	0	0
	NS	PM	PM	NS	PS	0	NS	NM
e	0	PM	PS	0	0	NS	NM	NM
	PS	PS	PS	0	NS	NS	NM	NM
	PM	0	0	NS	NM	NM	NM	NB
	PB	0	NS	NS	NM	NM	NB	NB

Table 2: Adjusting rule of the ΔKI parameter

ΔK_I		e_c						
		NB	NM	NS	0	PS	PM	PB
	NB	0	0	NB	NM	NM	0	0
	NM	0	0	NM	NM	NS	0	0
	NS	0	0	NS	NS	0	0	0
e	0	0	0	NS	NM	PS	0	0
	PS	0	0	0	PS	PS	0	0
	PM	0	0	PS	PM	PM	0	0
	PB	0	0	NS	PM	PB	0	0

IV. SIMULATION AND APPLICATION RESULTS

A. Simulation Results

Simulation results of a 10-KV system have been carried out with software PSIM. The PPFs are turned at the 11th and 13th, respectively. The injection circuit is turned at the 6th. In this simulation, ideal harmonic current sources are applied. The dc-side voltage is 535 V. Simulation results with the conventional PI controller and the proposed current controller are shown in Figs (7). I_L, Is, If, Iapf and the error represent the load current, supply current, current though the injection capacitor, current through APF, and error of compensation

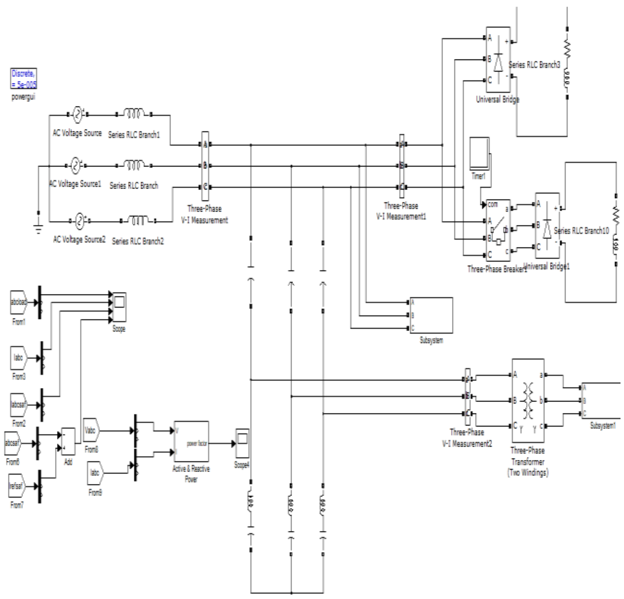

Figure 4: Simulation diagram of fuzzy based hybrid filter

The below figure 5. Shows the compensated voltage being injected in to the line whenever there is a sag in the transmission line due to unbalance faults in the line from the duration the duration 0.3 (s) to 0.5 (s)

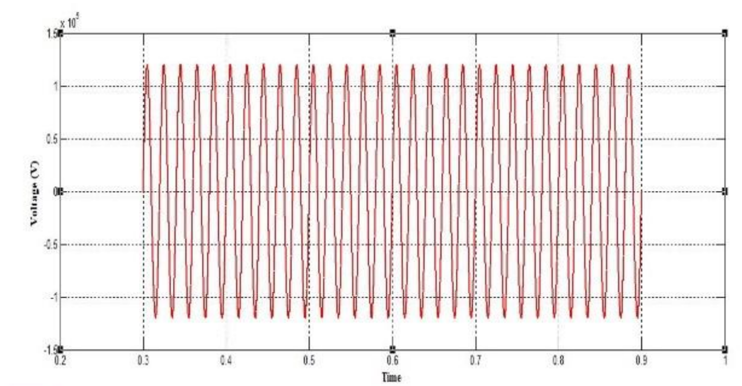

Figure 5: Compensated Voltage during Sag

The below figure 6. describes about the distortions in the RMS value of the line during voltage sag. In the existing system with PI as controller still there are deviations present with respect to injected voltage in to the line and also the harmonic content in rms values of injected voltages are considerable. With adaptive Fuzzy controller the variation in the rms line voltage after voltage compensation is minimized which be referred from the below 7.

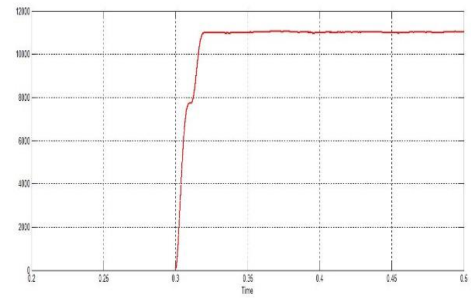

Figure 6: RMS voltage before compensation

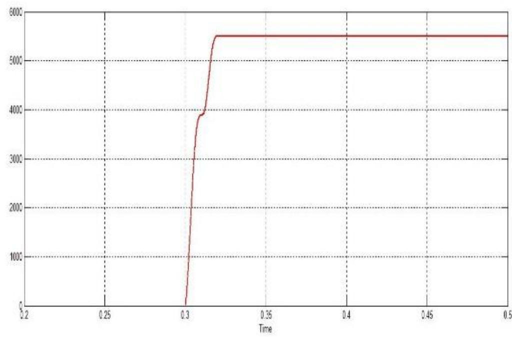

Figure 7: RMS voltage after compensation.

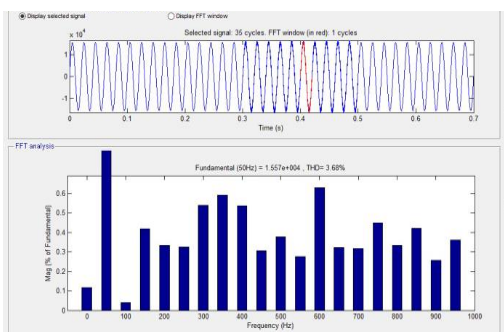

Figure 8: FFT analysis of Voltage sag of DVR-PI is 3.68%

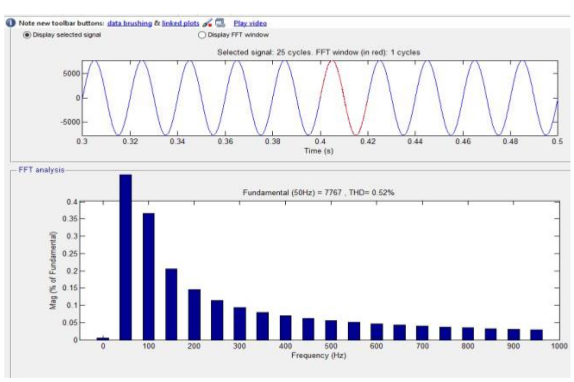

Figure 9: FFT analysis of voltage sag of DVR- Fuzzy controller is 0.52%

The total harmonic distortion even if we have sag it would be reduced when we place DVR at PCC as shown in figure 9.

V. CONCLUSION

To lessen the effects of power quality issues during various faults such three phase faults, single line to ground faults, and double line faults, DVR with Fuzzy Logic Controller has been developed. In MATLAB/Simulink, the investigation of outcomes performance has been successfully proven. The simulation demonstrates that the DVR's performance in reducing voltage sags and swells is adequate. The simulation findings further demonstrate that the DVR has good voltage management and promptly corrects for sags and swells. The supply voltage required to maintain the load voltage in a stable, balanced state at its nominal value.

VI. REFERENCES

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