MODELING AND ANALYSIS OF DVR USING DIFFERENT LOADING CONDITIONS

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Abstract--Power quality in electrical networks is one of the most concerned areas of electrical power system. Due to the use of non-linear loads and variation of load, various power quality problems such as sag, swell, harmonics, waveform distortion, voltage fluctuation occurs which result in malfunctioning of equipment. This paper is mainly concentrated to improve power factor, mitigate power quality problem and thereby reduction in THD to least minimum value can be obtained by using DVR. In DVR, shunt APF is designed to compensate the load current with supply voltage of 380V. Simulation results of DVR with PI or FUZZY controller are obtained with different load conditions using MATLAB.

Keywords--DVR; power quality; harmonic mitigation; Active Power Filter

I. INTRODUCTION

The use of non-linear load and variation of loads get increased which leads to poor power quality. With the impact of power electronic devices through the FACTS device, power quality problem is mitigated by improving power factor and thereby reducing THD. The wide range of development of power electronic devices such as Distribution Static Compensator (DVR), Static VAR Compensator (SVC), Dynamic Voltage Restoration (DVR), Uninterruptible Power Supplies (UPS), and Unified Power Quality Conditioner (UPQC) are available. Out of this to compensate the unbalance in supply voltage of different phases, DVR is connected in shunt with power system [1]. DVR is tested with different loading conditions in order to analyze the compensation of harmonics [2].

II. BASIC CONFIGURATION OF DVR

Dynamic voltage restoration (DVR) is a method of overcoming voltage sags that occur in electrical power distribution. It consists of Voltage Source Inverter (VSI) and DC link capacitor. DC link capacitor is connected with shunt APF used for the correction of individual voltage dips [3]. Here shunt APF used along with the coupling transformer by using primary voltage in phase with secondary voltage.

III. PROPOSED CONTROL STRATEGY OF DVR

The model of DVR with PI and FUZZY controller in MATLAB using power system block set is developed. The proposed model of DVR is shown in Fig 1 and the reference current generation of the proposed control strategy is shown in Fig 2.

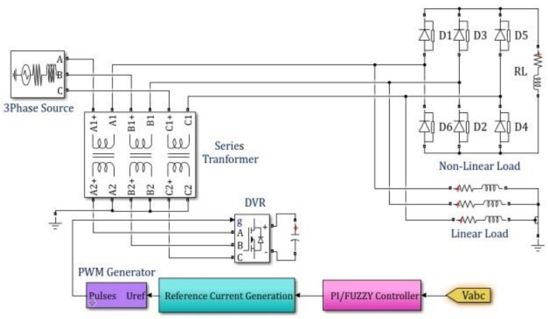

Fig. 1. Proposed model of DVR

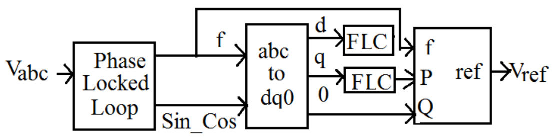

Fig. 2. Generation of reference current

Real power, reactive power and frequency are considered to find the reference current by using the following formula,

$$I_{ref} = Q\sin(2\pi ft + \theta - P) \qquad (1)$$

Where "P" & "Q" are represents real and reactive power. Real power is obtained by using fuzzy/PI controller, Sin_Cos values and frequency are obtained using Phase Locked Loop (PLL) [4], d-q-0 values are get from park's transformation and the necessary reactive power is obtained using Fuzzy/PI controller from 'd'.

A. Proposed Control Strategy of DVR with PI Controller

DVR is used to mitigate voltage sag, improve power factor and mitigate power quality problem [5]. For this PI controller is used along with DVR, the reference voltage is compared with the actual voltage and is fed to controller input and the controller output is duty cycle which is given to PWM generator used for providing gate pulses to shunt APF

B. Proposed Control Strategy of DVR with Fuzzy Controller

To implement DVR with fuzzy controller, the reference voltage is compared with the actual voltage and an error is developed [6]. The error and change in error are processed through fuzzy controller. The controller output duty cycle is fed to the PWM generator which is used for providing gate pulses to shunt APF. The membership function is used to define error, change in error and duty cycle and which is shown in Fig 3.

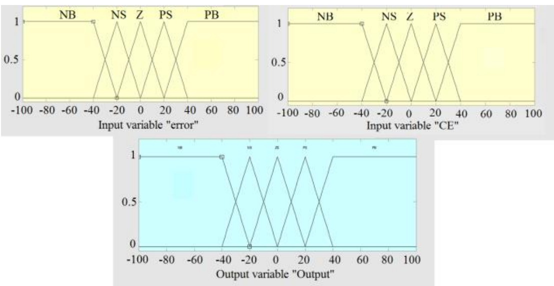

Fig. 3. Membership function of DVR

Fuzzy rule is shown in Table I and the corresponding linguistic variables are shown in Table II.

TABLE I. FUZZY RULES

MF	NB	NS	ZE	PS	PB
NB	NB	NB	NS	NS	ZE
NS	NB	NS	NS	ZE	PS
ZE	NS	NS	ZE	PS	PS
PS	NS	ZE	NS	PS	PB
PB	ZE	PS	ZE	PB	PB

TABLE II. LINGUISTIC VARIABLES

Linguistic variables	
NB	Negative Big
NS	Negative Small
ZE	Zero
PS	Positive Big
PB	Positive Small

IV. SIMULATION RESULTS AND DISCUSSION

If the harmonics in the power system increases which leads to malfunction of electrical equipment, protection relays, incorrect readings on meters etc. which affects the performance of the entire system [7]. Without the use of FACTS device, THD is raised high.

By using FACTS device in power system, power quality problems are mitigated, power factor gets improved and corresponding THD get decreases. The simulation of compensation system with the implementation of DVR using PI and fuzzy controller with various load conditions such as linear load, non-linear load, linear & non-linear load with breaker and linear & non-linear load without breaker.

A. Simulation of DVR Using PI Controller with Linear Load

The simulation of compensation system with the implementation of DVR with linear load using PI Controller is shown in Fig 4. The load current and current after compensation is shown in Fig 5 and the corresponding THD is shown in Fig 6.

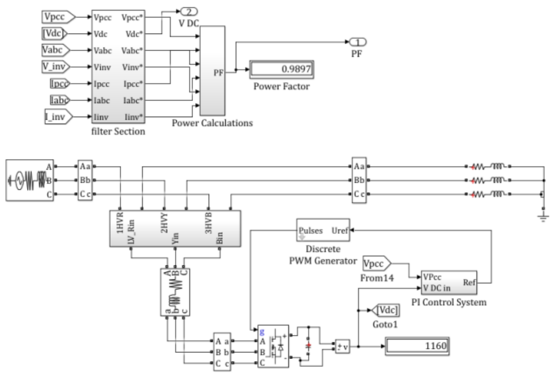

Fig. 4. Implementation of DVR using PI controller with linear load

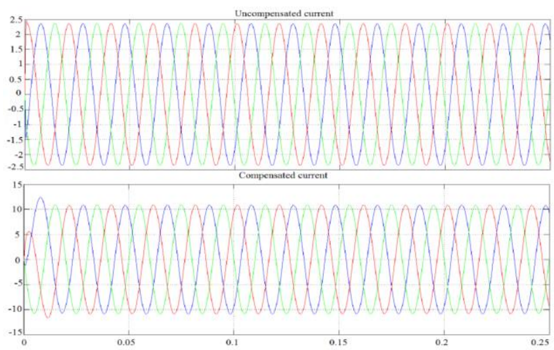

Fig. 5. Load current and compensated current using PI controller with linear load

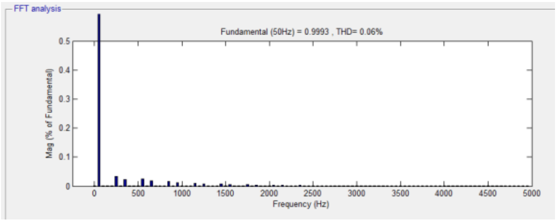

Fig. 6. FFT analysis of load current using PI controller with linear load

B. Simulation of DVR Using PI Controller with Non-Linear Load

The simulation result of compensation system with the implementation of DVR with non-linear load using PI controller is shown in Fig 7. The load current and current after compensation is shown in Fig 8 and the corresponding THD is shown in Fig 9.

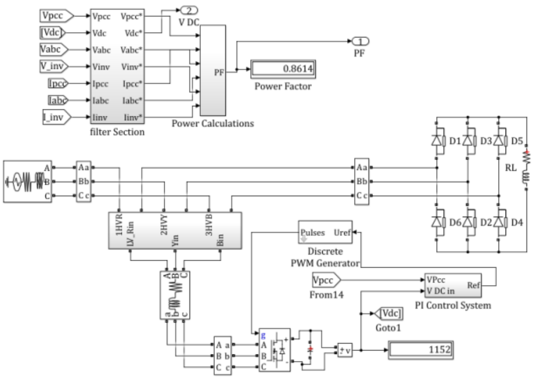

Fig. 7. Implementation of DVR with PI controller using non-linear load

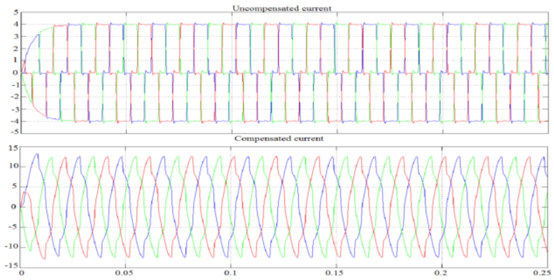

Fig. 8. Load current and compensated current using PI controller with non-linear load

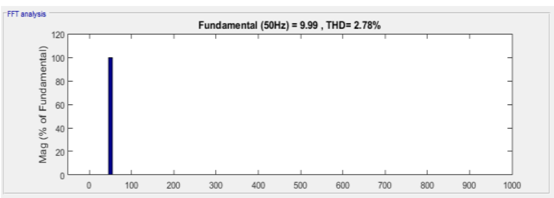

Fig. 9. FFT analysis of load current using PI controller with non-linear load

C. Simulation of DVR Using PI Controller with Linear and Non-Linear Load with Breaker

The simulation result of compensation system with the implementation of DVR with linear and non-linear load with breaker using PI controller is shown in Fig 10. The load current and current after compensation is shown in Fig 11 and the corresponding THD is shown in Fig 12.

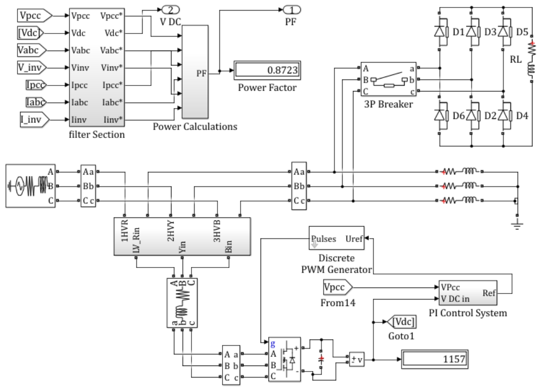

Fig. 10. Implementation of DVR with PI controller using linear and non-linear load with breaker

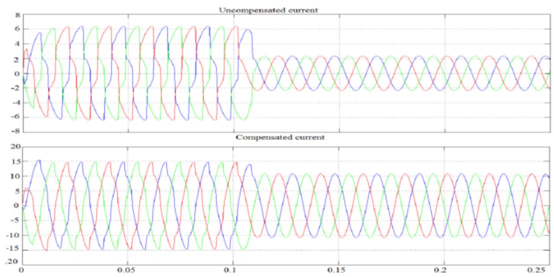

Fig. 11. Load current and compensated current using PI controller with linear and non-linear load with breaker

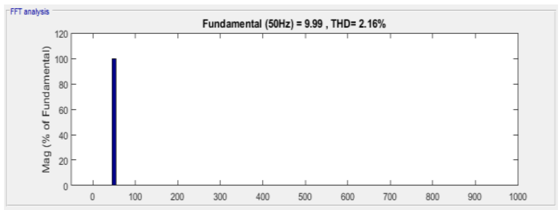

Fig. 12. FFT analysis of load current using PI controller with linear and non-linear load with breaker

D. Simulation of DVR Using PI Controller with Linear and Non-Linear without Breaker

The simulation result of compensation system with the implementation of DVR with linear and non-linear load without breaker using PI controller is shown in Fig 13. The load current and current after compensation is shown in Fig 14 and the corresponding THD is shown in Fig 15.

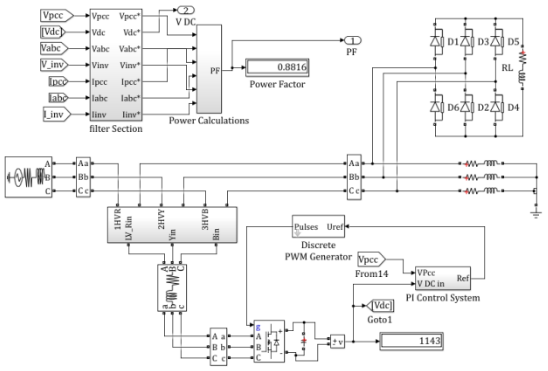

Fig. 13. Implementation of DVR using PI controller with linear and non-linear load without breaker

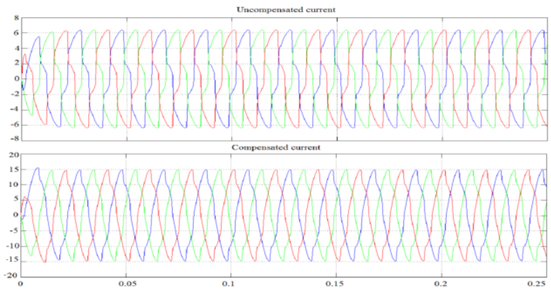

Fig. 14. Load current and compensated current using PI controller with linear and non-linear load without breaker

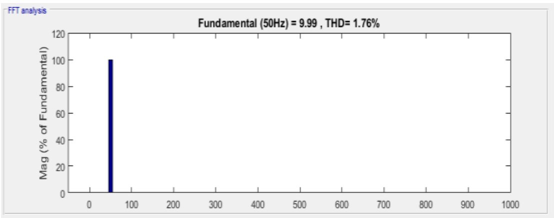

Fig. 15. FFT analysis of load current using PI controller with linear and non-linear load without breaker

E. Simulation of DVR Using Fuzzy Controller with Linear Load

The simulation of compensation system with the implementation of DVR with linear load using fuzzy controller is shown in Fig 16. The load current and current after implementation of DVR is shown in Fig 17 and the corresponding THD is shown in Fig 18.

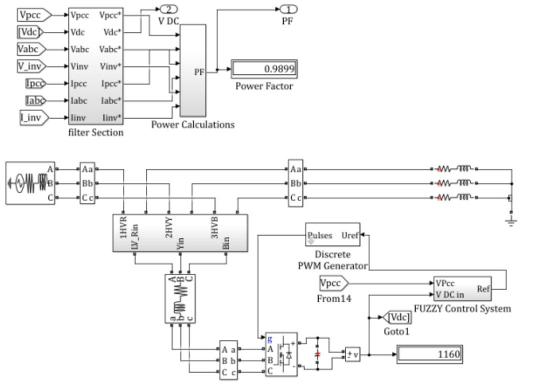

Fig. 16. Implementation of DVR using fuzzy controller with linear load

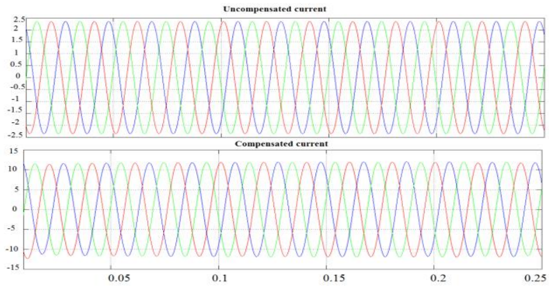

Fig. 17. Load current and compensated current using fuzzy controller with linear load

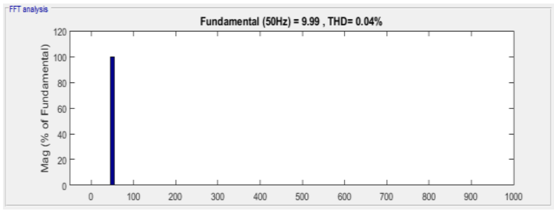

Fig. 18. FFT analysis of load current using fuzzy controller with linear load

F. Simulation of DVR Using Fuzzy Controller with Non-Linear Load

The simulation result of compensation system with the implementation of DVR with non-linear load using fuzzy controller is shown in Fig 19. The load current and current after implementation of DVR is shown in Fig 20 and the corresponding THD is shown in Fig 21.

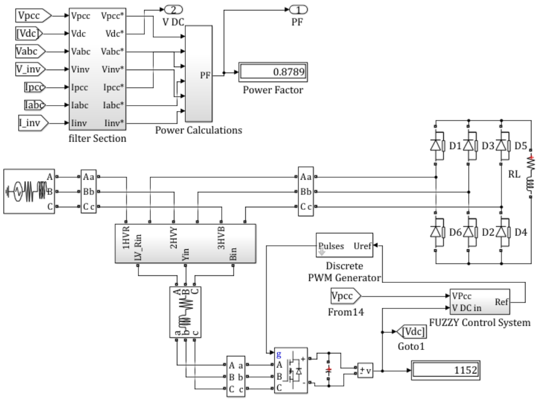

Fig. 19. Implementation of DVR using fuzzy controller with non-linear load

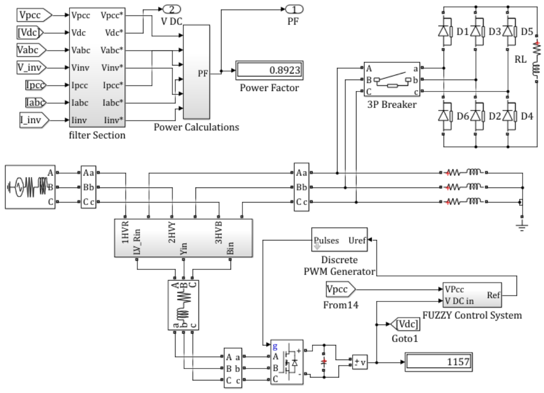

Fig. 22. Implementation of DVR using fuzzy controller with linear and non-linear load with breaker

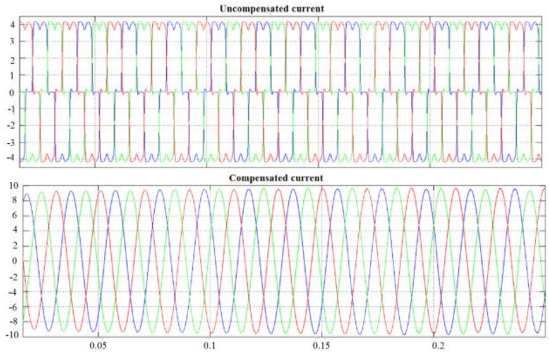

Fig. 20. Load current and compensated current using fuzzy controller with non-linear load

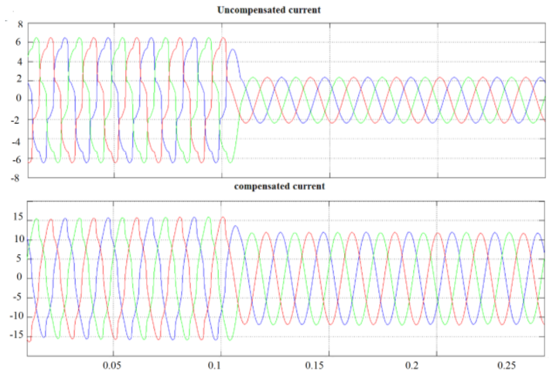

Fig. 23. Load current and compensated current using fuzzy controller with linear & non-linear load with breaker

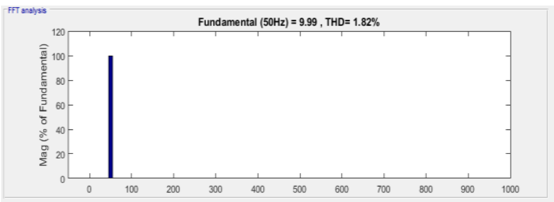

Fig. 21. FFT analysis of load current using fuzzy controller with non-linear load

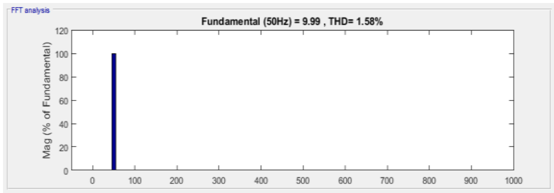

Fig. 24. FFT analysis of load current using fuzzy controller with linear and non-linear load with breaker

G. Simulation of DVR Using Fuzzy Controller with Linear and Non-Linear Load with Breaker

The simulation result of compensation system with the implementation of DVR with linear and non-linear load with breaker using fuzzy controller is shown in Fig 22. The load current and current after compensation is shown in Fig 23 and the corresponding THD is shown in Fig 24.

H. Simulation of DVR Using Fuzzy Controller with Linear and Non-Linear Load without Breaker

The simulation result of compensation system with the implementation of DVR with linear and non-linear load without breaker using fuzzy controller is shown in Fig 25. The load current and current after compensation is shown in Fig 26 and the corresponding THD is shown in Fig 27.

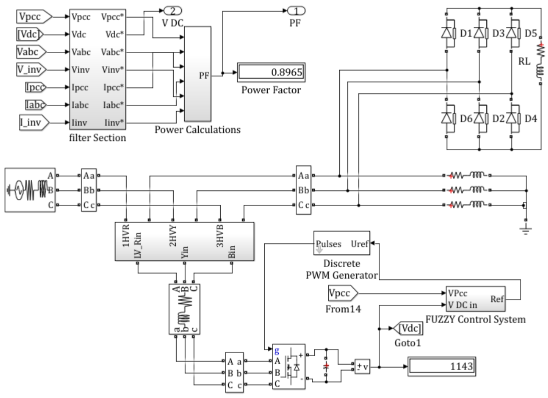

Fig. 25. Implementation of DVR using fuzzy controller with linear and non-linear load without breaker

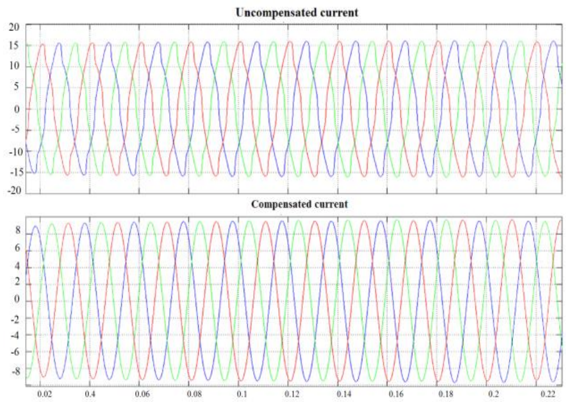

Fig. 26. Load current and compensated current using fuzzy controller with linear and non-linear load without breaker

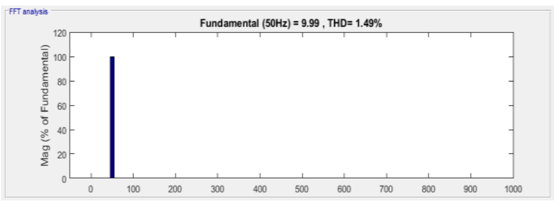

Fig. 27. FFT analysis of load current using fuzzy controller with linear and non-linear load without breaker

I. Comparison of Simulation Results

The comparison of DVR using PI or fuzzy controller using different perspective loads is shown in Table III.

TABLE III. PERFORMANCE COMPARISON OF DVR

Case No.	Description	Power Factor	THD (%)
1	DVR using PI controller with linear load	0.9897	0.06
2	DVR using PI controller with non-linear load	0.8614	2.78
3	DVR using PI controller with linear and non-linear load with breaker	0.8723	2.16
4	DVR using PI controller with linear and non-linear load without breaker	0.8816	1.76
5	DVR using fuzzy controller with linear load	0.9899	0.04
6	DVR using fuzzy controller with non-linear load	0.8789	1.82
7	DVR using fuzzy controller with linear and non-linear load with breaker	0.8923	1.58
8	DVR using fuzzy controller with linear and non-linear load without breaker	0.8965	1.49

From Table 3, it is obvious that DVR with linear load using fuzzy controller gives best results when compared to other cases.

V. CONCLUSION

This paper presents the enhancement of power quality in power system using DVR. The power quality problems obtained in the power system are mitigated, THD is reduced and power factor gets improved using custom power device along with proposed control strategy. The simulation of DVR with PI/fuzzy controller is done by using MATLAB. From the simulation results and by comparing the DVR with different state of loads, it is clear that the proposed DVR using fuzzy controller with linear load and non-linear load without breaker has power factor of 0.8965 and THD of 1.49% shows outstanding performance for improving power factor, power quality and reducing harmonics.

REFERENCES

[1] Akanksha V.Ital, Sumit A.Borakhade, "Compensation of Voltage Sags and swells by using Dynamic Voltage Restorer (DVR)", International Conference Electrical, Electronics and optimization techniques (ICEEOT), 2016.

[2] S.R.Reddy, P.V.Prasad, G.N.Srinivas, "Performance Comparison of DVR by Various Compensation Methods", 2014

[3] Ragini saxena, Manorma Kushwah, "Optimization Of Voltage Sag/Swell Using Dynamic Voltage Restorer (DVR)", International Conference on Electrical, Electronics, and Optimization Techniques (ICEEOT), 2016.

[4] Bibhu Prasad Ganthia, Samprati Mohanty, Prashanta Kumar Rana, Preeti Kumari Sahu, "Compensation of Voltage Sag Using DVR with PI Controller", International Conference on Electrical, Electronics, and Optimization Techniques (ICEEOT), 2016.

[5] Gagandeep Singh Dua, Raminder Kaur, "Enhancement of Power Quality in Distribution Network using DVR", IEEE INDICON, 2015

[6] S.Sathish Kishore, Sushant Kumar Sinha, Mrs.P.Abirami, Mrs. Merin Lizbeth George, "Voltage Sag Reductio n and Power Quality Improvement using DVR, "International Conference on Computation of Power, Energy, Information and Communication (ICCPEIC)", 2017.

[7] J. Bangarraju, V. Rajagopal, Sabha Raj AryaSabha Raj .Arya, B. Subhash, "Control of DVR using SPLL Strategy in Distribution System", 2016.