International Journal for Multidisciplinary Research (IJFMR)
E-ISSN: 2582-2160 ● Website: www.ijfmr.com ● Email: editor@ijfmr.com

Power Quality Improvement Using Dvr

M.J.Praveen[1], M Siva Ramakrishna[2], A.Venkata Yesu Babu[3], Chapala Jyothi[4], Chekka Vijay Krishna[5], A.Satya Prabha Navya Sudha[6]

[1]Assistant Professor, Department of Electrical and Electronics Engineering, VSM college of Engineering, Ramachandrapuram, Andhra Pradesh, India
[2,3,4,5,6]UG Students, Department of Electrical and Electronics Engineering, VSM college of Engineering, Ramachandrapuram, Andhra Pradesh, India

Abstract
Power Quality is an essential concern in the modern power system that can affect consumers and utility. The integration of renewable energy sources, smart grid systems and extensive use of power electronics equipment caused myriad problems in the modern electric power system. Current and voltage harmonics, voltage sag, and swell can damage the sensitive equipment. These devices are susceptible to input voltage variations created by interference with other parts of the system. Hence, in the modern age, with an increase in sensitive and expensive electronic equipment, power quality is essential for the power system's reliable and safe operation.Dynamic Voltage Restorer (DVR) is a potential Distribution Flexible AC Transmission System (D-FACTS) device widely adopted to surmount the problems of non-standard voltage, current, or frequency in the distribution grid. It injects voltages in the distribution line to maintain the voltage profile and assures constant load voltage. The simulations were conducted in MATLAB/Simulink to show the DVR-based proposed strategy's effectiveness to smooth the distorted voltage due to harmonics.A power system model with a programmable power source is used to include 3rd and 5th harmonics. The systems' response for load voltage is evaluated for with and without DVR scenarios. It has been noted that the proposed DVR based strategy has effectively managed the voltage distortion, and a smooth compensated load voltag.

INTRODUCTION

POWER QUALITY problems in the present-day distribution systems are addressed in the literature due to the increased use of sensitive and critical equipment pieces such as communication network, process industries, and precise manufacturing processes. Power quality problems such as transients, sags, swells, and other distortions to the sinusoidal waveform of the supply voltage affect the performance of these equipment pieces. Technologies such as custom power devices are emerged to provide protection against power quality problems. Custom power devices are mainly of three categories such as series-connected compensators known as dynamic voltage restorers (DVRs), shunt-connected compensators such as distribution static compensators, and a combination of series and shunt-connected compensators known as unified power quality conditioner. The DVR can regulate the load voltage from the problems such as sag, swell, and harmonics in the supply voltages. Hence, it can protect the critical consumer loads from tripping and consequent losses. The custom power devices are developed and installed at consumer point to meet the power quality standards such as IEEE-519. But ind The power system is divided into the following parts as generation, transmission, distribution, and by using other transmission line power systems is fed to different loads on the distribution side. Power quality plays a vital role in the power system when variable power is supplied to the load. Subsequently, the domestic and industrial customers with delicate loads are affected by the poor quality of power. Even there is various type of load on the distribution side, but poor power quality affects the sensitive loads more than others. There are many applications where the sensitive load has an increasing demand, like in hospital's operation theatres, semiconductor systems in processing plants, database systems, instruments to control air pollution in crowded areas, precise and accurate equipment are required by data processing, and service providers. If the power system causes the dips and distorted voltages, these devices may fail, and such a device's failure leads to wastage of a significant amount of money. Therefore, the distribution side is dependent on power quality. Electrical characteristics are set by the power system that does not disturb the system's performance and perform its function in a controlled manner. In this paper, voltage swell and distorted voltage with high harmonics in it are discussed. When the load voltage being disturbed, it causes voltage sag, transient, swell, and high distorted voltage with harmonics and Total Harmonic Distortion (THD) due to the occurrence of the faults. The vulnerability of voltage sags and harmonics problems is mostly to the delicate instruments. Few problems occur in the result of voltage sag that may also cause disturbance of torques in the motors, device burning, misfiring in the device, etc. The harmonic is an essential issue for power quality to be solved effectively.

LITERATURE SURVEY

J. W. Liu and S. S. Choi [Il The design of step dynamic voltage regulator is considered for the purpose of restoring load voltage without incurring excessive phase angle shift. As a type of custom power device devoid of any significant energy-storage capability, the process of voltage restoration by the regulator has to depend on the power in-feed from an external supply system. As a consequence, the analysis shows that there are inherent limits imposed on the device for achieving successful voltage restoration. Pertinent expressions are derived which relate the limits to the parametric values describing the supply system and loads. When the expressions are used in conjunction with a proposed computational procedure, a method to determine suitable regulator design for the purpose of power quality enhancement is obtained. Arindam Ghosh, Amit Kumar Jindal and Avinash Joshi [21 The paper discusses the operating principles and control characteristics of a dynamic voltage restorer (DVR) that protects sensitive but unbalanced and/or distorted loads. The main aim of the DVR is to regulate the voltage at the load terminal irrespective of sag/swell, distortion, or unbalance in the supply voltage. In this paper, the DVR is operated in such a fashion that it does not supply or absorb any active power during the steady-state operation. Hence, a dc capacitor rather than a dc source can supply the voltage source inverter realizing the DVR. The proposed DVR operation is verified through extensive digital computer simulation studies. Ambrish Chandra, Bhim Singh, B.

N. Singh and Kamal Al-Haddad [31 This paper deals with an implementation of a new control algorithm for a three-phase shunt active filter to regulate load terminal voltage, eliminate harmonics, correct supply power factor, and balance the nonlinear unbalanced loads. A three-phase insulated gate bipolar transistor (IGBT) based current controlled voltage source inverter (CC-VSI) with a dc bus capacitor is used as an active filter (AF). The control algorithm of the AF uses two closed loop PI controllers. The dc bus voltage of the AF and three-phase supply voltages are used as feed back signals in the PI controllers. The control algorithm of the AF provides three-phase reference supply currents. A carrier wave pulse width modulation (PWM) current controller is employed over the reference and sensed supply currents to generate gating pulses of IGBT's of the AF. Test results are presented and discussed to demonstrate the voltage regulation, harmonic elimination, power- factor correction and load balancing capabilities of the AF system.

EXISTING SYSTEM

The traditional power distribution network faces various voltage quality issues such as sags, swells, and harmonics due to faults, load variations, and switching transients. Conventional methods to mitigate these issues include tap-changing transformers and automatic voltage regulators (AVRs), which help maintain voltage stability but have slow response times. Uninterruptible Power Supply (UPS) systems provide temporary power backup and voltage regulation but are expensive and not practical for large-scale distribution systems. Static VAR Compensators (SVCs) and STATCOMs improve voltage stability by injecting reactive power; however, they have limitations in handling deep voltage sags and harmonics effectively. Passive filters are commonly used for harmonic reduction, but they are bulky, have fixed compensation capabilities, and may cause resonance problems. Additionally, conventional Dynamic Voltage Restorers (DVRs) often rely on proportional-integral (PI) or proportional- integral-derivative (PID) controllers, which have slower response times and limited adaptability to dynamic disturbances. To overcome these limitations, an advanced control strategy using an Artificial Neural Network (ANN)-based DVR is proposed, offering faster response, better adaptability, and improved compensation for voltage disturbances.

PROPOSED SYSTEM

Neural networks have been used in a broad range of Electrical applications. Artificial intelligence technologies viz., expert systems (ES) and ANNs. In recent years, another term 'intelligent control' has come to embrace diverse methodologies combining conventional control and emergent techniques based on physiological metaphors, such as ANNs, fuzzy logic, ANNs have been studied for many years with the hope of understanding and achieving human-like computational performance. The benefits include massive parallelism, architectural modularity, fast speed, high fault tolerance and adaptive capability. NN applications to power systems can be categorized under three main areas: regression, classification and combinatorial optimization. Applications involving include transient stability analysis, load forecasting, static and dynamic stability analysis. The area of combinational optimization includes unit commitment and governing control Artificial Neural Network (ANN) as a computing system is made up of a number of simple, and highly interconnected processing elements, which processes information by its dynamic state response to external inputs. In recent times the Study of the ANN models is gaining rapid and increasing importance because of their potential to offer solutions to some of the problems which have hitherto been intractable by standard serial computers in the areas of computer science and artificial intelligence. Neural networks are better suited for achieving human-like performance in the fields such as speech processing, image recognition, machine vision, robotic control, etc.

Artificial neural network modeling:

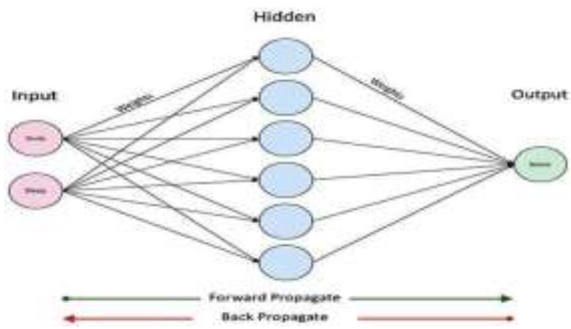


Fig1.Ann modeling

COi = f (EWij Ij)

1. Its output, in turn, can serve as input to other units.
2. The weighted sum is called the net input to unit i, often written net.
3. Note that wij refers to the weight from unit j to unit i (not the other way around).
4. The function f is the unit's activation function. In the simplest case, f is the identity
5. function, and the unit's output is just its net input. This is called a linear unit.

1.Single Layer Perceptron (SLP) Model :

Perceptron is the simplest single layer network, considered as a linear classifier.

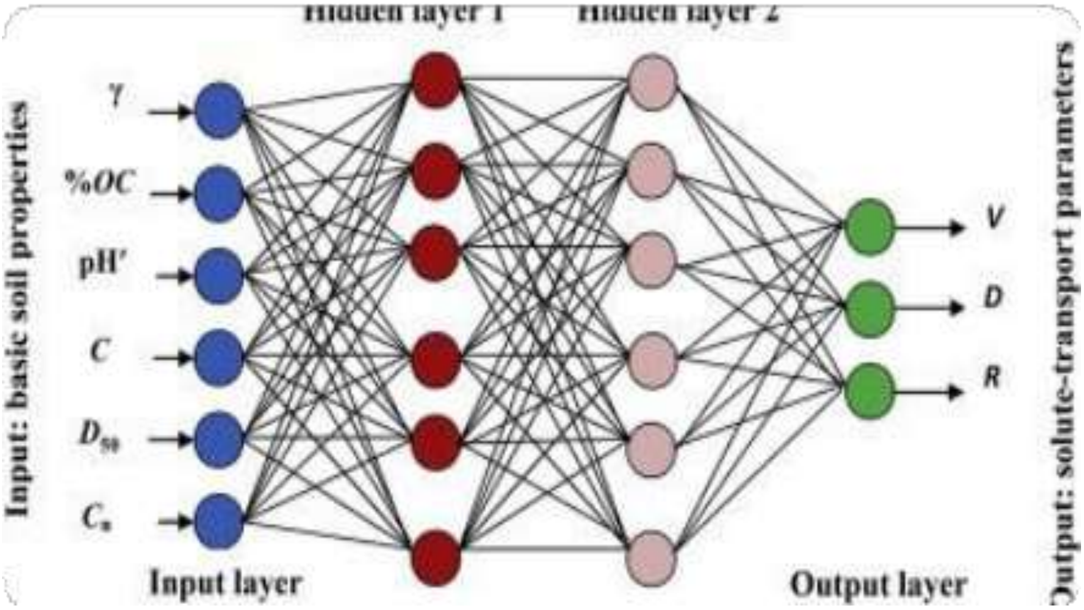
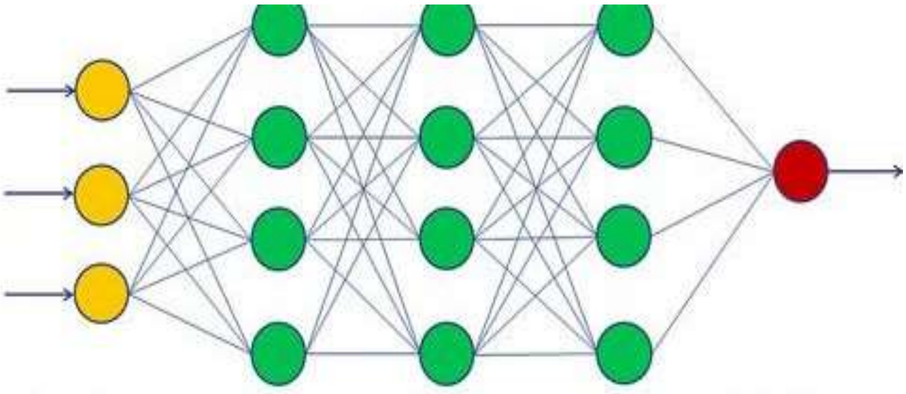
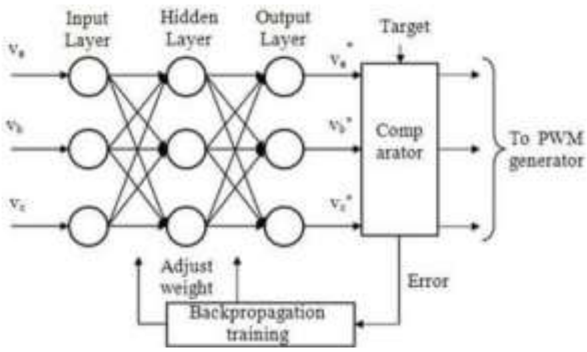


Fig2. Single layer network

2.Multi Layer Perceptron (SLP) Model :



To improve the performance of the compensating device, a multilayer back propagation type ANN controller is used. The MATLAB toolbox is used to train ANN. The training algorithm used in the ANN controller is Levenberg Marquardt Back propagation algorithm. Gradient Descent (GD) Method is the first order optimization algorithm, and it is used to find a local minimum of a given function. This method is robust when it starts far of the final minimum; however, it has poor final convergence. The LM back propagation algorithm is the second order optimization, and it interpolates between the GD and the Gauss Newton (GN) algorithm. The LM algorithm is more robust, and it finds a solution even if it does begin very far from the final optimum. The LM algorithm is the best by comparing GN algorithm and GD method.



Faster convergence, low memory required and capable learning are also the advantages of using Leven bergmarquardt back propagation algorithm. All the values are used to train the ANN are taken from conventional PI controller. The designed ANN controller has 3 layers composed of 2 input layers, 10 hidden layers and I output layer. The input of the ANN controller is the error and change in error signals from both d and q coordinates system, which is the difference between actual value and reference value. The minimization of the error is the target expected in ANN controller. The output of the ANN controller, is converting dqo to abc components. Mean square error is the performance function of the ANN controller, which is the error between input and target values. Fig. ANN Controller The ANN training is stopped, if the number ofmaximum epoch to train is reached or the time is beyond the maximum limit or the performance is minimized to the goal or the performance gradient falls below minimum gradient or initial blending factor (mu) beyond maximum mu or the performance of the validation has increased more than the Maximum validation failures. In this work the number of approach required to train the ANN in d-coordinate is 67 and the best validation performance is 0.00030248 at epoch 61. In q-coordinate the total number of epochs is 81 and the best validation performance is 0.032883 at epoch 75. The ANN is trained offline and it is designed to control the DVR. After the completion of offline training the generated ANN controller is placed in the replacement of PI controller. The Discrete PWM (Pulse Width Modulation) pulse generator generates firing pulses to trigger IGBT switches.

SIMULATION AND ITS RESULTS:

PI Controller:

The DVR-connected system consisting of a three-phase supply, three-phase critical loads, and the series injection transformers is modelled in MATLAB/Simulink environment along with a sim power system toolbox. An equivalent load considered is a 10-kVA 0.8-pf lag linear load.

The control algorithm for the DVR is also modeled in MATLAB. The reference DVR voltages are derived from sensed PCC voltages (vsa,vsb,vsc) and load voltages (vLa,vLb,vLc). A PWM controller is used over the reference and sensed DVR voltages to generate the gating signals for the IGBTs of the VSC of the DVR. The capacitorsupported DVR is also modeled and simulated in MATLAB, and the performances of the systems are compared in three conditions of the DVR.

Performance of the DVR System:

The performance of the DVR is demonstrated for different supply voltage disturbances such as voltage sag and swell. Fig. 6.1 shows the transient performance of the system under voltage sag and voltage swell conditions. At

0.2 s, a sag in supply voltage is created for five cycles, and at 0.4 s, a swell in the supply voltages is created for five cycles. It is observed that the load voltage is regulated to constant amplitude under both sag and swell conditions. PCC voltages Vs, load voltages VL, DVR voltages Vc, amplitude of load voltage VL and PCC voltage Vs, source currents Is, reference load voltages VLref, and dc bus voltage Vdc are also depicted in Fig. 6.1. The load and PCC voltages of phase A are shown in Fig. 6.2, which shows the in-phase injection of voltage by the DVR. The compensation of harmonics in the supply voltages is demonstrated in Fig. 6.3. At 0.2 s, the supply voltage is distorted and continued for five cycles. The load voltage is maintained sinusoidal by injecting proper compensation voltage by the DVR. The total harmonics distortions (THDs) of the voltage at the PCC, supply current,

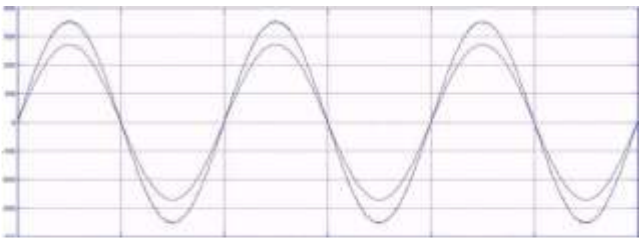


Fig. 6.2 Voltages at the PCC and load terminals for PI controller.

and load voltage are shown in Figs. 6.4—6.6, respectively. It is observed that the load voltage THD is reduced to a level of 0.71% from the PCC voltage of 6.41%. The magnitudes of the voltage injected by the DVR for mitigating the same kinds of sag in the supply with different angles of injection are observed. The injected voltage, series current, and kilo volt ampere ratings of the DVR for the four injection schemes are given in Table

6.1. In Scheme-I in Table 6.1, the in-phase injected voltage is Vinjl in the phasor diagram in Fig. 4.2. In Scheme-2, a DVR voltage is injection at a small angle of 30^0, and in Scheme-3, the DVR voltage is injected at an angle of 45 ^{0} . The injection of voltage in quadrature with the line current is in Scheme-4. Tm4s)

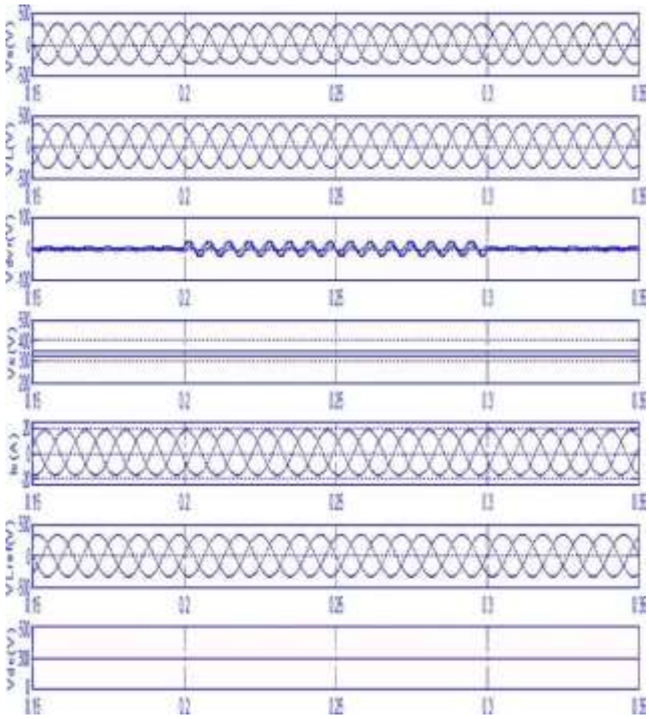


Fig. 6.3 Dynamic performance of DVR during harmonics in supply voltage applied to critical load for PI controller.

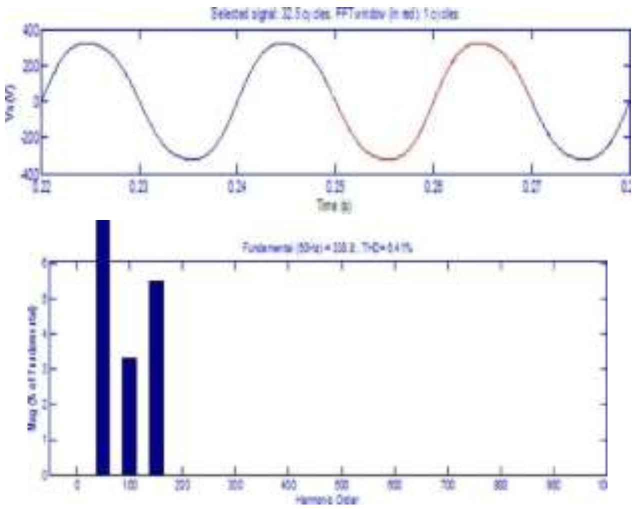


Fig. 6.4 PCC voltage and harmonic spectrum during the disturbance for PI controller.

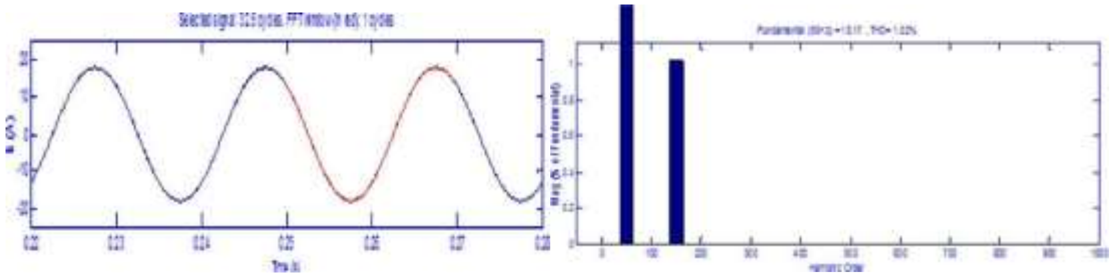


Fig.6.5 Supply current and harmonic spectrum during the disturbance for PI controller

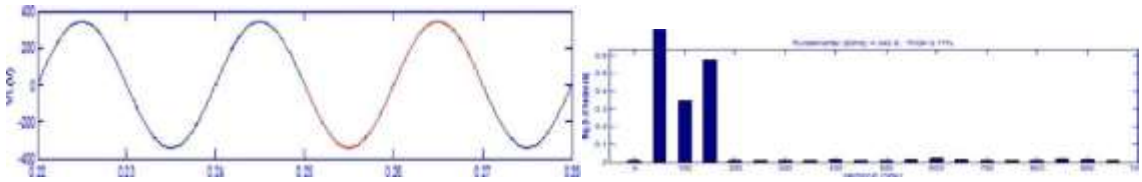
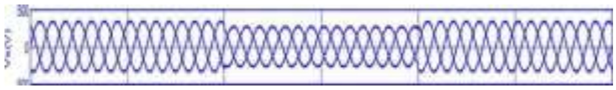
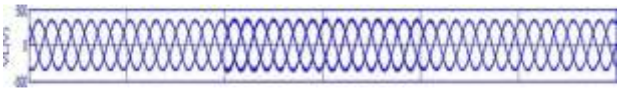


Fig.6.6 Load voltage and harmonic spectrum during the disturbance for PI controller.

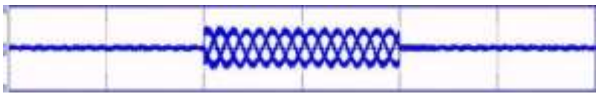
The required rating of compensation of the same using Scheme-I is much less than that of Scheme-4.The performance of the self-supported DVR (Scheme-4) for compensation of voltage sag is shown in Fig. 6.7(a) and that of a voltage swell is shown in Fig. 6.7(b). It is observed that the injected voltage is in quadrature with the supply current, and hence, a capacitor can support the dc bus of the DVR. However, the injected voltage is higher compared with an inphase injected voltage (Scheme-I).



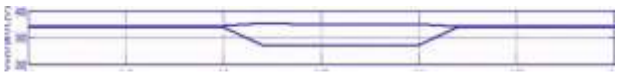
.4 0.45 0.5 0.55 0.6
0.65 0.7



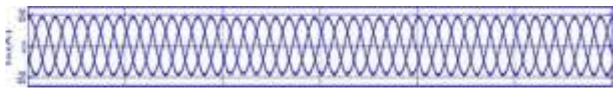
0.4 0.45 0.5 0.55 0.6
0.65 0.7
200



-200
0.4 0.45 0.5 0.55 0.6
0.65 0.7

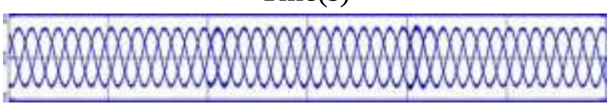


0.4 0.45 0.5 0.55 0.6
0.65 0.7

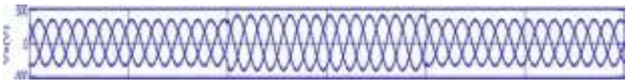


0.4 0.45 0.5 0.55 0.6
0.65 0.7

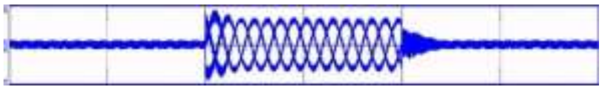
0.4 0.45 0.5 0.55 0.6
0.65 0.7
Tme(s)



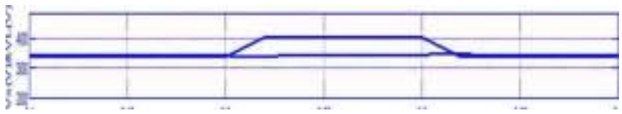
(a)



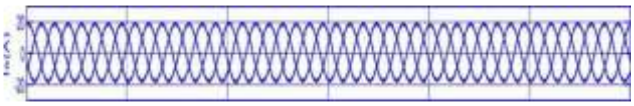
0.4 0.45 0.5 0.55 0.6
0.65 0.7
500



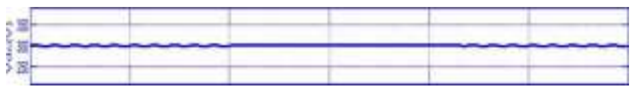
-500
0.4 0.45 0.5 0.55 0.6
0.65 0.7



100
-100
0.4 0.45 0.5 0.55 0.6
0.65 0.7



0.4 0.45 0.5 0.55 0.6
0.65 0.7
0.4 0.45 0.5 0.55 0.6
0.65 0.7



0.4 0.45 0.5 0.55 0.6
0.65 0.7

Fig. 6.8 Dynamic performance of DVR with in-phase injection during voltage sag and swell applied to critical load using ANN Controller.

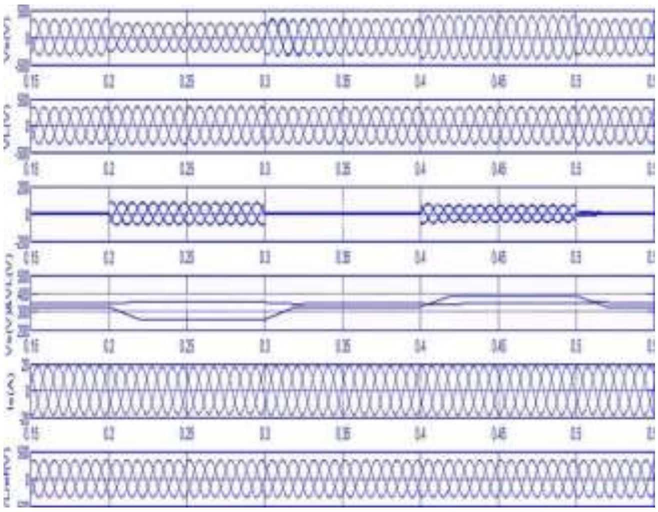
The control algorithm for the DVR is also modeled in MATLAB. The reference DVR voltages are derived from sensed PCC voltages (vsa,vsb,vsc) and load voltages (vLa,vLb,vLc). A Time(s)

(b)

Fig. 6.7 Dynamic performance of the capacitor-supported DVR during (a) voltage sag and (b) voltage swell applied to critical load for PI controller

ANN Controller:

The DVR-connected system consisting of a three-phase supply, three-phase critical loads, and the series injection transformers is modeled in MATLAB/Simulink environment along with a sim power system toolbox. An equivalent load considered is a10-kVA 0.8-pflag linear load.



> -500

o.15 0.2 0.25 0.3 0.35 0.4

0.45 0.5 0.55

0.3 0.35 0.4

0.45 0.5 0.55

Time(s)

PWM controller is used over the reference and sensed DVR voltages to generate the gating signals for the IGBTs of the VSC of the DVR. The capacitorsupported DVR is also modeled and simulated in MATLAB, and the performances of the systems are compared in three conditions of the DVR.

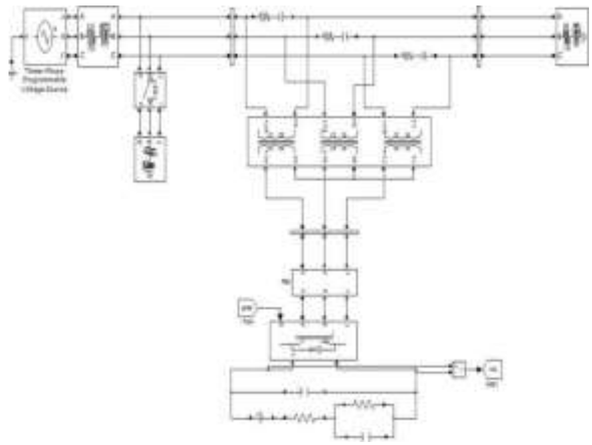


Fig. 6.9 Block diagram of power Quality improvement using DVR with BESS.

The performance of the DVR is demonstrated for different supply voltage disturbances such as voltage sag and swell. Fig. 6.8 shows the transient performance of the system under voltage sag and voltage swell conditions. At 0.2 s, a sag in supply voltage is created for five cycles, and at 0.4 s, a swell in the supply voltages is created for five cycles. It is observed that the load voltage is regulated to constant amplitude under both sag and swell conditions. PCC voltages Vs, load voltages VL, DVR voltages Vc, amplitude of load voltage VL and PCC voltage Vs, source

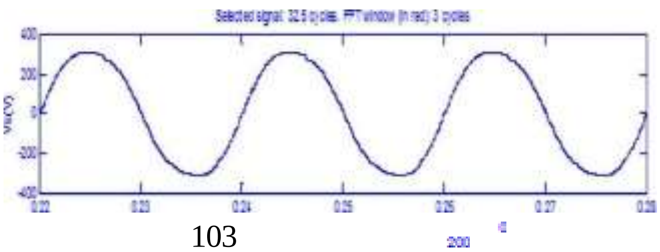
currents Is, reference load voltages VLref, and dc bus voltage Vdc are also depicted in Fig. 6.8. The load and PCC voltages of phase A are shown in Fig. 6.17, which shows the in-phase injection of voltage by the DVR. The compensation of harmonics in the supply voltages is demonstrated in Fig. 6.11. At 0.2 s, the supply voltage is distorted and continued for five cycles. The load voltage is maintained sinusoidal by injecting proper compensation voltage by the DVR.

The total harmonics distortions (THDs) of the voltage at the PCC, supply current,

0.22 0.23 0.24 0.25 0.26
0.27 0.28 Time(s)

Fig. 6.10 Voltages at the PCC and load terminals in ANN Controller.

and load voltage are shown in Figs. 6.12—6.14, respectively. It is observed that the load voltage THD is reduced to a level of 0.57% from the PCC voltage of 5.89%. The magnitudes of the voltage injected by the DVR for mitigating the same kinds of sag in the supply with different angles of injection are observed. The injected voltage, series current, and kilo volt ampere ratings of the DVR for the four injection schemes are given in Table 6.8. In Scheme-I in Table 6.8, the in-phase injected voltage is Vinjl in the phasor diagram in Fig. 1. In Scheme-2, a DVR voltage is injection at a small angle of 30^0 , and in Scheme-3, the DVR voltage is injected at an angle of 45^0 . The injection of voltage in quadrature with the line.



103

Fig. 6.12 PCC voltage and harmonic spectrum during the disturbance using ANN Controller.

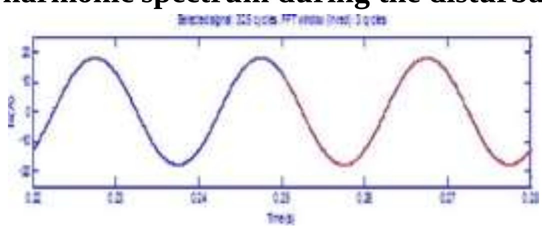


Fig.6.13 Supply current and harmonic spectrum during the disturbance in ANN Controller

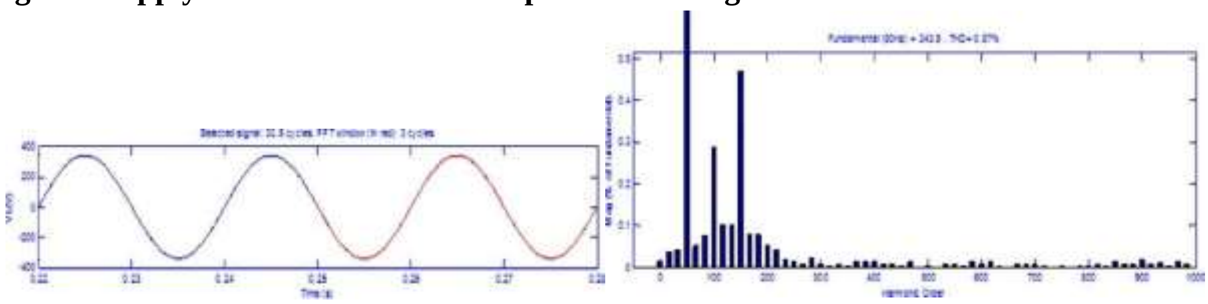


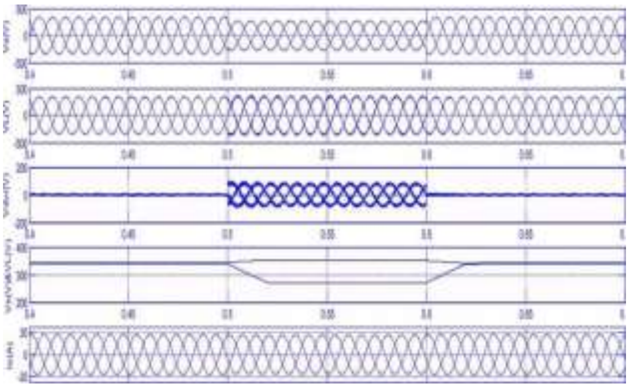
Fig.6.14 Load voltage and harmonic spectrum during the disturbance in ANN Controller.

current is in Scheme-4. The required rating of compensation of the same using Scheme-I is much less

International Journal for Multidisciplinary Research (IJFMR)

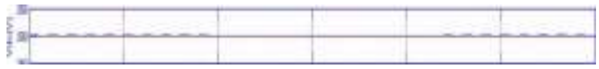
E-ISSN: 2582-2160 ● Website: www.ijfmr.com ● Email: editor@ijfmr.com

than that of Scheme-4.The performance of the self-supported DVR (Scheme-4) for compensation of voltage sag is shown in Fig. 6.15(a) and that of a voltage swell is shown in Fig. 6.15(b). It is observed that the injected voltage is in quadrature with the supply current, and hence, a capacitor can support the dc bus of the DVR. However, the injected voltage is higher compared with an inphase injected voltage (Scheme- 1).



0.40.45 0.5 0.55 0.6

0.65 0.7



0.40.45 0.5 0.55 0.6

0.65 0.7

Time(s)

(a)

Fig. 6.15 Dynamic performance of the capacitor- supported DVR during voltage sag

	PI Controller THD	ANN Controller THD
Source Voltage	6.41%	5.89%
Source Current	1.02%	0.98%
Load Voltage	0.71%	0.57%

Table 6.1 Comparative results

CONCLUSION

The operation of a DVR has been demonstrated with a new control technique using various voltage injection schemes. A comparison of the performance of the DVR with different schemes has been performed with a reduced-rating VSC, including a capacitor-supported DVR. The reference load voltage has been estimated using the method of unit vectors, and the control of DVR has been achieved, which minimizes the error of voltage injection. The SRF theory has been used for estimating the reference DVR voltages. It is concluded that the voltage injection in-phase with the PCC voltage results in minimum rating of DVR but at the cost of an energy source at its dc bus.

FUTURE SCOPE

By using battery energy storage system in combination with capacitor supported Dynamic Voltage

Restorer, the rating of the capacitor can be reduced. And by applying different injection schemes (in phase injection scheme) the cost of the voltage source converter and hence Dynamic Voltage Restorer minimized. So that the cost of protection equipment (like DVR) in communication network, process industries, and precise manufacturing processes are minimized.

REFERENCES

1. S. filtering capability of WECS with DFIG for grid power quality improvement,"[l] M. H. J. Bollen,Understanding Power Quality Problems—Voltage Sags and Interruptions. New York, NY, USA: IEEE Press, 2000.
2. A. Ghosh and G. Ledwich, Power Quality Enhancement Using Custom Power Devices. London, U.K.: Kluwer, 2002. [3] M. H. J. Boilen and 1. Gu, Signal Processing of Power Quality Disturbances. Hoboken, NJ, USA: Wiley-IEEE Press, 2006. [4]
3. R. C. Dugan, M. F. McGranaghan, and H. W. Beaty, Electric Power Systems Quality, 2nd ed. New York, NY, USA: McGraw-Hill, 2006.
4. A. Moreno-Munoz, Power Quality: Mitigation Technologies in a Distributed Environment. London, U.K.: Springer-Verlag, 2007.
5. K. R. Padiyar, FACTS Controllers in Transmission and Distribution. New Delhi, India: New Age Int., 2007.
6. IEEE Recommended Practices and Recommendations for Harmonics Control in Electric Power Systems, IEEE Std. 519, 1992.
7. V. B. Bhavraju and P. N. Enjeti, "An active line conditioner to balance voltages in a three phase system,"IEEE Trans. Ind. Appl., vol. 32, no. 2, pp. 287— 292, Mar./Apr.
8. 1996. [9] S. Middlekauff and E. Collins, "System and customer impact," IEEE Trans. Power Del., vol. 13, no. 1, pp. 278- 282, Jan. 1998.
9. M. Vilathgamuwa, R. Perera, S. Choi, and K. Tseng, "Control of energy optimized dynamic voltage restorer," inProc. IEEE IECON, 1999, vol. 2, pp. 873-878.
10. J. G. Nielsen, F. Blaabjerg, and N. Mohan, "Control strategies for dynamic voltage restorer compensating voltage sags with phase jump," inProc.IEEE APEC, 2001, vol. 2, pp. 1267-1273.
11. A. Ghosh and G. Ledwich, "Compensation of distribution system voltage using Trans. Power Del., vol. 17, no. 4, pp. 1030-1036,Oct. 2002.