Simulation and Implementation of Dynamic Voltage Restorer

Neha H. Chaudhari and Bijal Mehta
Electrical Engineering Department
Sarvajanik College of Engineering and Technology
Surat, India.
e-mail: nehachaudhari1619@gmail.com

***ABSTRACT*-Voltage sag remains a serious power quality (PQ) problem by being the most common and causing more economic losses. As the solution of power quality problems related to voltage and current, a custom power device is constructed which is named as Dynamic voltage restorer (DVR). Selecting an appropriate topology for DVR provides better solution of any power quality issues. DVR remains present in circuit as a buffer device during normal voltage supply and controlled independently. For the sag detection purpose DVR has implemented an algorithm based on dq-0 transformation. The proposed algorithm is designed to operate correctly even during disturbance and varying fault condition. DVR has a large energy storage element as a source for compensation purpose and that can perform for sever sags and specific long duration sag. Hence the overall performance of DVR based on sag detection time period and its compensation is excellent.**

I. INTRODUCTION

Power quality is a term that means different things to different people. The IEEE 1100 Standard identify power quality the same as "the concept of powering and grounding sensitive electronic equipment in a manner that is suitable to the operation of that equipment." Power quality might also be defined as "the measure, analysis, and improvement of bus voltage, usually a load bus voltage, to maintain that voltage to be a sinusoid at rated voltage and frequency." Another clarity of power quality is, "the provision of voltages and system design so that the user of electric power can utilize electric energy from the distribution system successfully without interference or interruption." Simpler explanation of power quality is," power quality is a set of electrical boundries that allows a piece of equipment to function in its manner without significant loss of performance"

Power quality is one of today's most concerned areas of electric power system. The power quality has serious economic implications for consumers, utilities and electrical equipment manufacturers. For power quality crossing point such integration of non-conservative technologies fuel cells, wind turbines and photovoltaic are necessary with utility grids. The power electronic systems also provide to power quality troubles. Under the deregulated environment, in which electric utilities are possible to compete with each other, the user's agreement becomes very necessary. The contact of power quality troubles is all the time more felt by users industrial, commercial and even residential Sources of poor Power Quality are listed as follows

- Adjustable –speed drives
- Switching Power supplies
- Arc furnaces
- Electronic

III. POWER QUALITY ISSUES

Voltage Sag: Voltage sag is identified as the lessening of rms voltage to a value between 0.1 and 0.9 p. u and enduring for period between 0.5 cycle to 1 minute. Voltage sags are frequently cause by system faults and last for period range from 3 cycles to 30 cycles depending on the fault clearance time. It is to be noted that under voltages can be handle by voltage dip as the motor draws a current up to 10 times the full load current during the starting. Also, the power factor of the starting current is generally poor.

ISSN 2229-5518

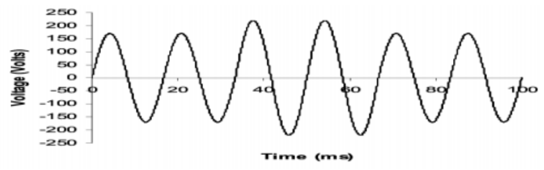


Fig1.3.2: Voltage Swell

Interruption: If the deliver voltage or load current reduce to minus than 0.1 p. u for a period of time not more than one minute is identified as interruption. Interruption can be cause by system faults, equipment failure or control malfunction. The period due to a fault is decide by the operating time of the protective device. some interruption may also be caused by voltage sag conditions when the rare faults on the supply side.

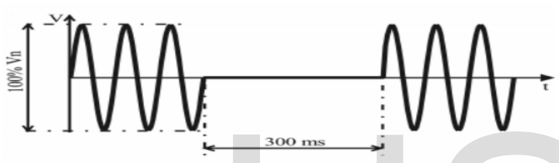


Fig1.3.3: Voltage Interruption

IV. SOLUTIONS TO POWER QUALITY PROBLEMS

The mitigation of power quality problems can be achieved in two ways. The solution to the power quality can be done from customer side or from utility side. First method is called load conditioning and the other method is line conditioning. Load conditioning ensures that the equipment is less sensitive to power disturbances, allowing the operation even under significant voltage distortion while the instalment of line conditioning systems suppresses or counteracts the power system disturbances. They are depending on PWM converters and connected in shunt or in series to low and medium voltage distribution system. Series active power filters must operate in conjunction with shunt passive filters in order to compensate the load current harmonics. Series active power filters operates as a controllable voltage source whereas shunt active power filters operate as a controllable current source.

(i) Lightening and Surge Arresters: Arresters are designed for lightening the protection of transformers, but these are not sufficient for limiting voltage to protect sensitive electronic control circuits from voltage surges.

(ii) Thyristor Based Static Switches: The static switch is a device for switching a new element into the circuit when the voltage support is needed. It has dynamic response time of about one cycle. It may be used in the alternate power line applications. To correct quickly for voltage spikes, sags or interruptions, the static switch may used to switch one or more of devices such as filter, capacitor, alternate power line, energy storage systems etc.

(iii) Energy Storage Systems: Storage systems may be used to protect sensitive production equipments from shutdowns due to voltage sags or momentary interruptions. The energy is fed to system for compensate for the energy that will lost by the voltage sag or interruption. These are usually DC storage systems such as batteries, UPS, superconducting magnet energy storage (SMES), storage capacitors or even fly wheels driving DC generators. The output of these devices can be supplied to the system through an inverter on a momentary basis.

(iv) Electronic Tap Changing Transformer: A voltage-regulating transformer with an electronic load tap changer may be used with a single line from the utility. It may regulate the voltage drops up to 50% and requires a stiff system (short circuit power to load ratio of 10:1or better).

(v) Harmonic Filters: Filters are used to reduce or eliminate harmonics. It is always advantage able to use a 12-pluse or higher transformer connection, rather than a filter. Usually, multiple filters are needed, each tuned to a separate harmonic. Each filter causes a parallel resonance as well as a series resonance, and each filter slightly changes the resonances of other filters.

The report begins by presenting the basic system topologies for DVRs and comparing them with respect to rating in power and voltage. This report of four different system topologies for dynamic voltage restorers (DVRs) are analyzed and tested, with particular focus on the methods used to acquire the necessary energy during voltage sag. Comparisons are made between two

International Journal of Scientific & Engineering Research Volume 11, Issue 1, January-2020 384
ISSN 2229-5518

topologies that can be realized with a minimum amount of energy storage, with energy taken from the grid during the voltage sag, and two topologies that take energy from stored energy devices during the voltage sag. This comparison ranks the no-storage topology with a passive shunt converter on the load side first, followed by the stored energy topology with a constant dc-link voltage.

V. OVERVIEW OF TOPOLOGIES FOR DVR

DVRs operate to maintain the load supply voltage at its rated value. The systems considered in this paper are all three-phase, and only active power flow is considered in the analysis of their rating requirements. For the purposes of this comparison, it is assumed that the load has a high-power factor and the passive converter absorbs only active power. During voltage sag, the DVR injects a voltage to restore the load supply voltages. In this mode the DVR exchanges active and reactive power with the surrounding system. If active power is supplied to the load from the DVR, it needs a source for this energy. Two types of system are considered here, one using stored energy to supply the delivered power and the other having no significant internal energy storage Basic principal of Dvr is to transfer the voltage sag and swell compensation value from Dc side of the inverter to the injected transformer after filter. The compensation capacity of a particular DVR depends on the maximum voltage injection capability and the active power that can be supplied by the DVR. The main function of the DVR is the protection of sensitive loads from voltage sags/swells coming from the supply network. Power electronic converter injects appropriate voltage based on voltage sag. It is fast, flexible, & efficient solution to voltage sag problem

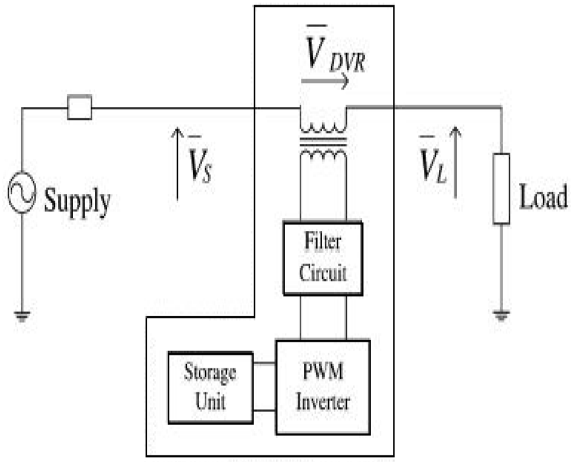


Fig. Basic block diagram of Dynamic Voltage Restorer

VI.SAG DETECTION METHOD

One of the most important requirements for DVR is that the controller should be able to operate in real time manner. It means that the whole compensating process is carried out immediately, after a failure occurs, without any delay. The very important factor that influences the DVR speed most is the reaction time of the implemented voltage sag detection algorithm. The best DVR systems are able to react within 1 ms.

There are several voltage sags detection techniques, which can be used in DVR, such as:

- Peak value method
- Missing voltage method
- RMS method
- Discrete Fourier transformation
- DQ transformation
- Hybrid transformation

✈ DQ transformation (dq0 – *direct-quadrature-zero*)

dq transformation is a mathematical transformation used to simplify the analysis of three-phase circuits. d and q quantities

ISSN 2229-5518

represent rectangular two axis system, which rotates with angular frequency ω in the case of symmetric three-phase system, introducing of the dq0 transformation reduces three AC quantities (pu) to two DC quantities (d=1, q=0). Any deviations from the steady state condition in abc system reflect in changes of dq0 values in real-time. For unbalanced and asymmetric three phase system applies d≠0, q≠0, 0≠0. According to this presumption it is possible to obtain the difference between desired and instant values dynamically. Therefore, the output compensating voltage can be controlled by PID regulators \The resultant signal is converted back to abc values.

VII. MATLAB SIMULATION

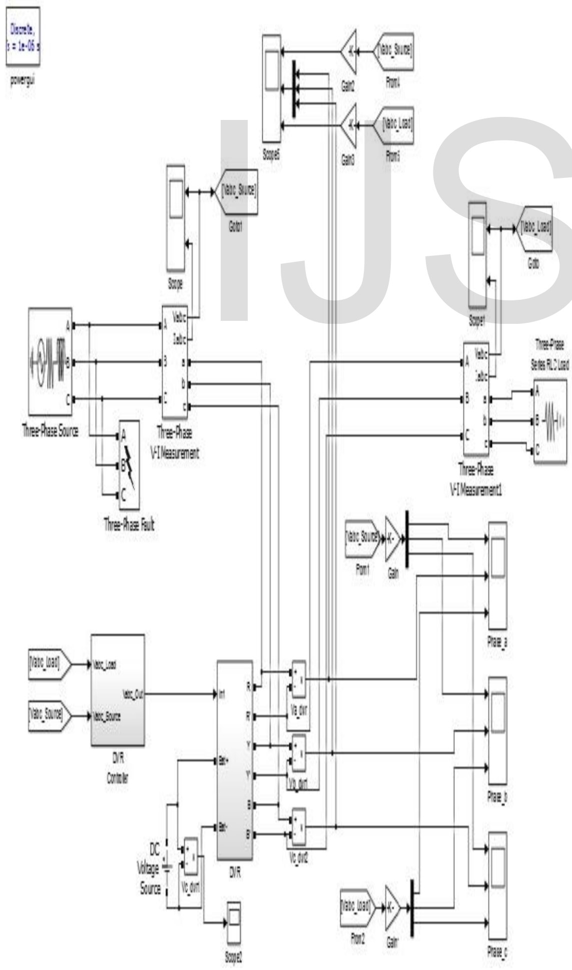


Fig.simulation model of Dynamic voltage restorer

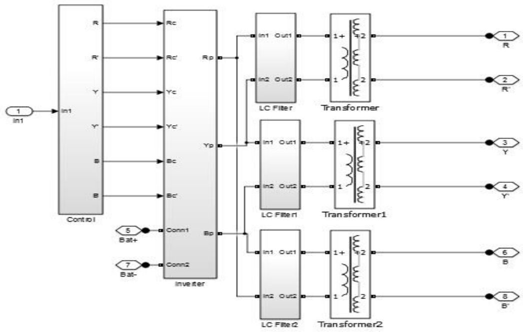


Fig.simulation model of dynamic voltage restorer

MATLAB SIMULATION RESULT

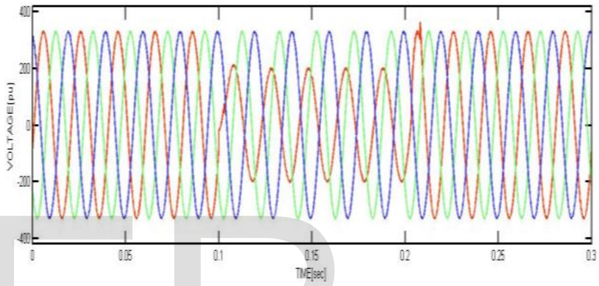


Fig. voltage before DVR (Phase A)

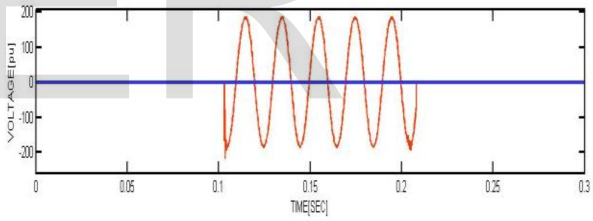


Fig. Injected voltage (Phase A)

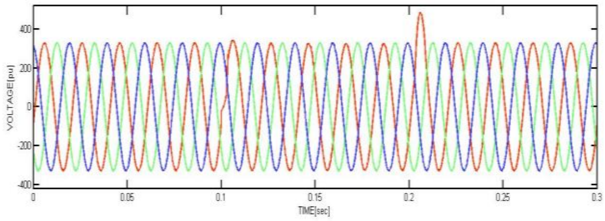


Fig. Compensated voltage (Phase A)

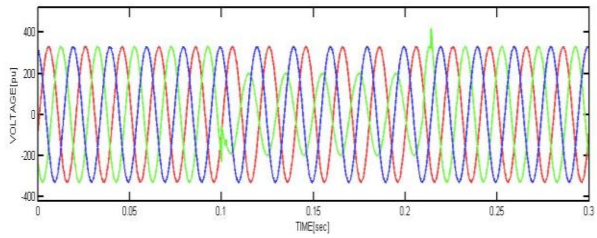


Fig. voltage before DVR (Phase B)

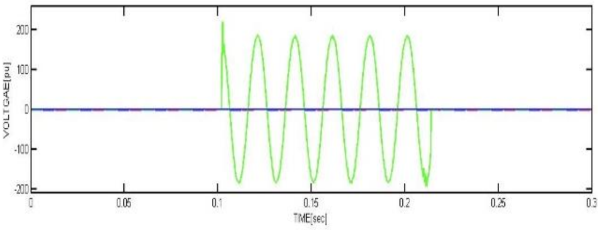


Fig. Injected voltage (Phase B)

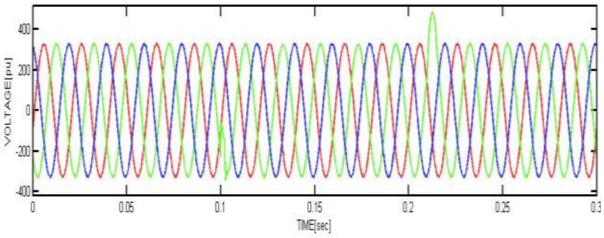


Fig. Compensated voltage (Phase B)

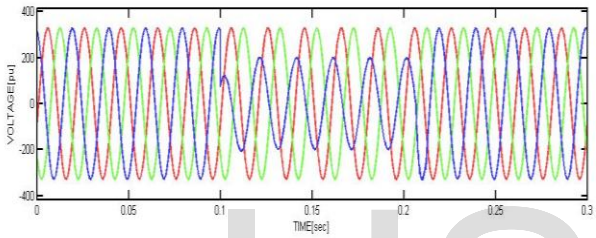


Fig. Voltage before DVR (Phase C)

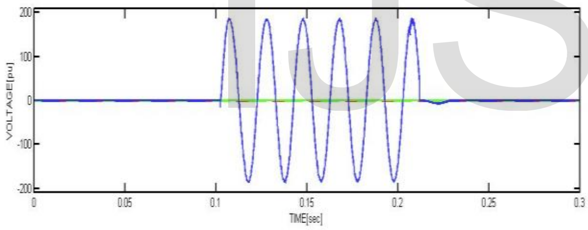


Fig. Voltage before DVR (Phase C)

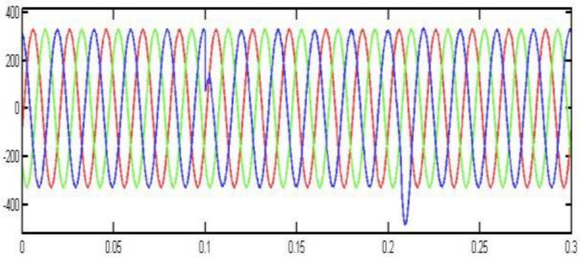
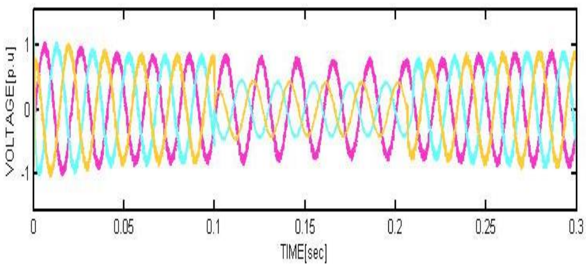
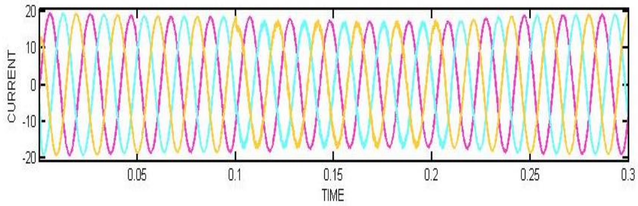
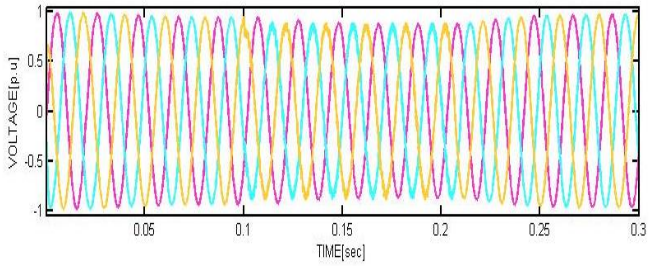


Fig. Compensated voltage (Phase C)







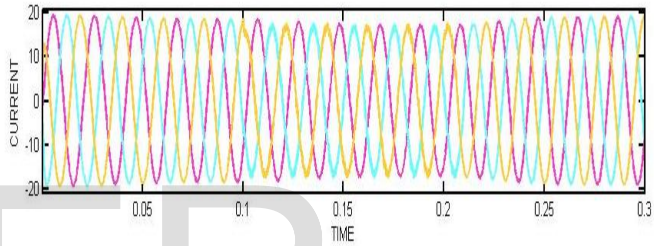
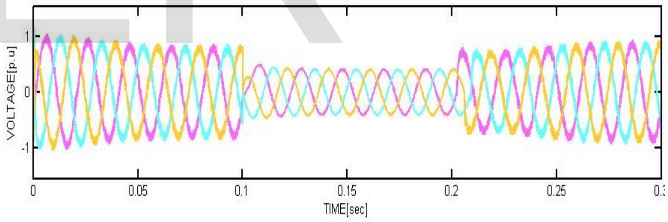
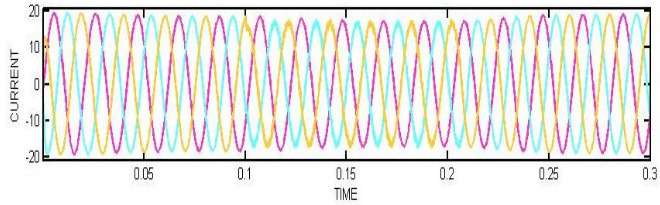
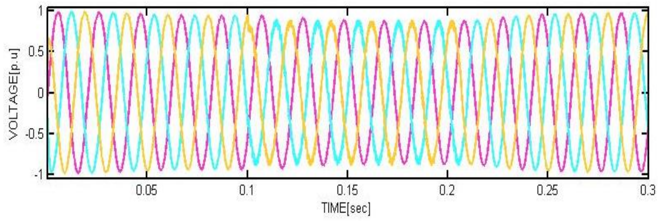


Fig. Two phase voltage/current waveform result before/after Dvr







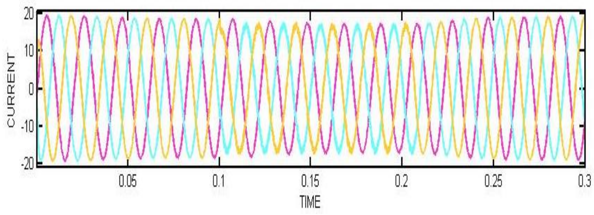


Fig three phase voltage/current sag waveform result before/after Dvr

VIII. CONCLUSION

By simulating the DVR model, it can provide excellent voltage regulation against the power quality issues and prevents the connection from breakdown or any other damage. For control technique of DVR system dq-transformation control technique is used because it provides high speed control, system simplicity and can be used even during distorted supply voltage waveform. Because of the advanced control technique, DVR responses to the power quality issue and injects the appropriate voltage to the load by measuring the source voltage and desired v

IX. REFERENCES

1. John Godsk Nielsen and Freed Bleiberg, Fellow, "A Detailed Comparison of System Topologies for Dynamic Voltage Restorers" *IEEE Transactions on industry applications, Vol.41, No.5, September/ 2005.*

2. Takushi, IEEE, Hideaki Fujita, Member, IEEE, and Hirofumi Akagi, Fellow, "Design and Experimentation of a Dynamic Voltage Restorer Capable of Significantly Reducing an Energy-Storage Element" *IEEE Transactions on industry applications, Vol.44, No. 3, May/June 2008.*

3. John Gods Nielsen, Michael IEEE, Hans Nielsen, "Control and Testing of a Dynamic Voltage restorer" *IEEE Transactions of Power Electronics Vol.19. No.3 May 2004*

4. Babaei, m. Farhadi Kangarlu, and M. Sabahi, "Mitigation of voltage disturbances using dynamic voltage restorer based on direct converters," *IEEE Trans. Power Del., vol. 25, no. 4, pp. 2676-2683, Oct. 2010*

5. E. Babaei, M. Farhadi Kangarlu, and M. Sabahi, "Mitigation of voltage disturbances using dynamic voltage restorer based on direct converters," *IEEE Trans. Power Del., vol. 25, no. 4, pp. 2676-2683, Oct. 2010*

6. Ahad. Kazemi and Ali. Azhdast "Implementation of a Control Strategy for Dynamic Voltage Restorer (DVR) and Dynamic Voltage Compensator (DVC)". Lidong Zhang and Math H. J. Bollen, Senior Member, "Characteristic of Voltage Dips (Sags) in Power Systems" *IEEE Transactions on power delivery, Vol.15, No.2, April 2000.*

7. L. D. Zhang and M. H. J. Bollen, "Characteristic of voltage dips (sags) in power systems," *IEEE Trans. Power Del., vol. 15, no. 2, pp. 827–832, Apr. 2000.*

8. M.H.J. Bollen, “The influence of motor re-acceleration on voltage sags,” *IEEE Trans. on Industry Applications, vol. 31, pp. 667–674, 1995.*

9. J. G. Nielsen, F. Blaabjerg, and N. Mohan, “Control strategies for dynamic voltage restorer compensating voltage sags with phase jump,” in Proc. *IEEE APEC’01, vol. 2, 2001, pp. 1267–1273.*

10. J. Praveen, B. Muni, S. Venkatesh and H. Makthal, "Review of dynamic voltage restorer for power quality improvement," in Proc. *2004 IEEE Industrial Electronics Society Engineering Society Conf., pp. 749-754.*

11. J. Nielsen, M. Newman, H. Nielsen, and F. Blaabjerg, "Control and testing of a dynamic voltage restore(dvr) at medium voltage level," *IEEE Trans. Power Electron., vol. 19, no. 3, p. 806, May 2004.*

12. L. Conrad, C. Grigg, K. Little, "Predicting and preventing problems associated with remote fault clearing voltage dips," *IEEE Trans. Industry Applications, vol27, no. 1, pp. 167-172, Jan/Feb 1991.*

13. J. G. Nielsen, F. Blaabjerg, “A detailed comparison of system topologies for dynamic voltage restorers*,” IEEE Trans. Ind. Appl., vol. 41, no. 5, pp. 1272-1280, Sep./Oct. 2005.*

14. W.E. Brumsickle, R.S. Schneider, G.A. Luck jiff, D.M. Divan, and M.F. Cranachan, “Dynamic sag correctors: cost-effective industrial power line conditioning,” *IEEE Trans. Ind. Appl.*, vol. 32, no. 1, pp. 212-217, Jan./Feb. 2001.

15. C. Meyer, R.W. DeDoncker, Y.W. Li, and F. Blaabjerg, “Optimized control strategy for a medium-voltage DVR—theoretical investigations and experimental results,” IEEE Trans. Power Electron., vol. 23, no. 6, pp. 2746-2754, Nov. 2008.

16. E. Babaei, M. Farhadi Kangarlu, and M. Sabahi, “Compensation of voltage disturbances in distribution systems using single-phase dynamic voltage restorer*,” Electr. Power Syst. Res., vol. 80, no. 12, pp. 1413- 1420, Dec. 2010.*

17. H. Awad, J. Svensson, and M. Bollen, “Mitigation of unbalanced voltage dips using static series compensator,” IEEE Trans. Power Electron., vol. 19, no. 3, pp. 837–846, May 2004.

18. Y. Sekine *et al.*, “Voltage-sag compensation,” *Voltage-Sag Compensation Committee Rep. Electric Technol. Res. Assoc., vol. 46, no. 3, pp. 89–91, 1990. (in Japanese).*

19. J. D. Li, S. S. Choi, and D. M. Vilathgamuwa, “Impact of voltage phase

jump on loads and its mitigation," *in Proc. 4th Int. Power Electronics Motion Control Conf., vol. 3, Xian, China, Aug. 14–16, 2004, pp. 1762–1766.*

20. C. Fitzer, M. Barnes, and P. Green, "Voltage sag detection technique for a dynamic voltage restorer*," IEEE Trans. Ind. Appl., vol. 40, no. 1, pp. 203– 212, Jan./Feb.* 2004.

21. P. Cheng, C. Huang, C. Pan, and S. Bhattacharya, "Design and implementation of a series voltage sag compensator under practical utility conditions*," IEEE Trans. Ind. Appl., vol. 39, no. 3, pp. 844–853, May/Jun. 2003.*

22. H. Fujita, S. Tominaga, and H. Akagi, "Analysis and design of a DC voltage-controlled static var compensator using quad-series voltage source inverters*," IEEE Trans. Ind. Appl., vol. 32, no. 4, pp. 970–978, Jul./Aug. 1996.*

Fig. Voltage before DVR (Phase C)

Fig. Injected voltage (Phase C)

Fig. Compensated voltage (Phase C)