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Simulation of DVR with Hysteresis Voltage Control for Power Quality Improvement

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ABSTRACT

The dynamic voltage restorer (DVR) is a custom power device used for voltage compensation of sensitive loads against voltage disturbances in power distribution lines. 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. Different voltage injection schemes for dynamic voltage restorers (DVRs) are analyzed with particular focus on a new method used to minimize the rating of the voltage source converter (VSC) used in DVR. A new control technique is proposed to control the capacitor-supported DVR. The control of a DVR is demonstrated with a reduced-rating VSC. The reference load voltage is estimated using the unit vectors. The synchronous reference frame theory is used for the conversion of voltages from rotating vectors to the stationary frame. The results are presented by using Matlab/simulink software.

Keywords: Power Quality, Custom Power Devices, DVR, Control Strategies of DVR, Hysteresis Voltage Control.

1. INTRODUCTION

Now a day, because of large use of sensitive and nonlinear loads in electrical power systems and the rapid growth of renewable energy sources, the power quality problems are very important. The most regular power quality situations are voltage dip, voltage swell, and harmonic contents and so on. Because of the power quality disturbances, the many industrial consumers are strongly affected. With today's development towards deregulation and competition between utilities, the present issues of power quality are absolutely important. Voltage dip is described as a short drop in voltage waveforms, brought on by a shortcoming on the power system network. The definition of voltage dip is dependent upon two parameters, size and duration. To improve power quality, custom power devices are used. In 1995 the concept of custom power is first explained by Hingorani [1]. The thought of custom power (CP) identifies with the utilization of electronic controllers for power system network. There are number of custom power units which are given below, Distribution Statcom(D-STATCOM), Dynamic Voltage Restorer (DVR), Unified power quality conditioner (UPQC), Active Power Filters,BatterySystems(BESS),DistributionSeries Capacitors (DSC), Surge Arresters (SA), Uninterruptible Power Supplies (UPS), Solid State Fault Current Limiter (SSFCL), Solid-State Transfer Switches (SSTS), and Static Electronic Tap Changers (SETC) .The CPD devices are either connected in series or in shunt or combination of both. The aforementioned every unit has its particular profits and constraints. The DVR is recognized as successful sort of custom power unit due to its following advantages:

- It has capacity to manage the active power flow.
- It has less cost compared with others.
- It requires less maintenance
- It has higher energy capacity.
- DVR is more minor in size and expenses less compared with the DSTATCOM, likewise DVR recompenses the voltage dip , voltage swell, it can additionally included different features for example power factor correction and harmonics elimination. [2].

In this paper the hysteresis voltage control technique is used for controlling the dynamic voltage restorer and generation of switching pulses (gate pulses) for the inverter of DVR. The Hysteretic Voltage Control can provide fast transient response without additional loop compensation. With the benefits of low cost and ease of implementation, it's very popular for power supplies of microprocessors and other high-slew-rate transition loads. It is best explained in further section.

2. DYNAMIC VOLTAGE RESTORER

Dynamic voltage restorer is overall suited to secure susceptible or delicate load from short span voltage dips and swells. Whenever a short circuit happens in a power system network, a sudden voltage dip will show on nearby feeders. With a DVR introduced on a load feeder, the line voltage is restored to its normal level within the reaction time of a few milliseconds. Hence power interruption is avoided.

A. Design considerations for DVR

A commonly used series connected DVR is normally outlined to boost the missing voltage into the line through a

booster transformer. Its main purpose is to reduce the effect of voltage sag or swell. It can be also used for the reduction of harmonics. Following are the some considerations while designing the DVR [9].

Choice of the Power Switching Apparatus: Power electronics devices for the dynamic voltage restorer used at distribution level are MOSFETs or IGBT. When consider IGBTs, the MOSFETs are the very faster power switching apparatus. That means it has a higher Converter switching frequencies, because of higher switching frequencies the transient oscillations and harmonics (higher order) are eliminated.

Size of the Series Booster Transformer: The transformer size is relates with the saturation. To minimize saturation under all conditions, the coupling transformer utilized as a part of DVR must be estimated to handle anyhow double the standard steady-state flux necessity at most extreme rms injection voltage, without saturation. The total device cost is depends on the transformer cost.

Detection of Supply Side Transformer: The DVR must detect the supply side disturbances very accurately. It is the important task for the operation of DVR.

Proper Voltage Restoration: At the time of restoration, for the proper voltage injection the DC link voltage is maintained at appropriate level. For this purpose, the large or small DC capacitor bank can be used.

Control of Voltage: Control algorithm should be designed in such a way that, it controls the all the parameters of the DVR system, like voltage control

B. Structure of DVR

The following fig.1 describes the general structure of dynamic voltage restorer.

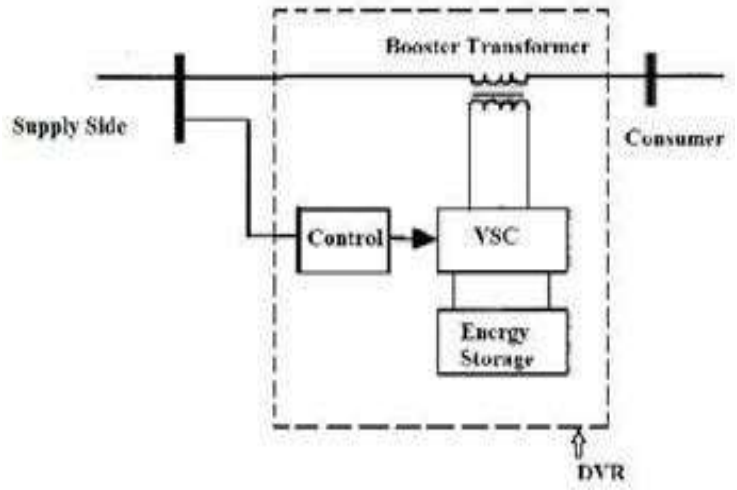

Fig.1. General DVR Structure.

The main components of dynamic voltage restorer are as follows:

Boost/injection Transformer: with the help of booster transformer the power is transformed to secondary side, and it is also used to reduce the coupling of noise.

Harmonic filter: Harmonic filter is utilized to eliminate the harmonic contents which are generated in pulse width modulation. for that purpose passive filters are used.

Inverter: by using the inverter the dc voltage waveforms are converted into ac voltage waveform. a voltage source inverter is power electronics mechanism utilized to create the sinusoidal voltage at any needed magnitude, frequency and phase angle. It comprises of power storage unit and switching unit.

Energy storage device: It is used to supply the necessary energy for the generation of injected voltage to voltage source inverter via DC link.

Capacitor: DVR consists of a capacitor having large rating. In addition, it is used for stiff DC voltage for the input of inverter.

By-Pass Switch: If the current present on the load side exceeds a reasonable value because of short circuit on the burden and huge inrush current, the DVR could be separated from the system by utilizing the bypass switches and supplying a different path for current.

C. Working of Dynamic Voltage Restorer

The working of dynamic voltage restorer is does not depends on fault type and any event that happened in the system as shown in Fig.2. There are three different modes i.e. Protection mode, Standby mode & Boost mode-of operation of dynamic voltage restorer which are explained below-

Injection/Boost Mode: DVR injects a missing voltage through the injection transformer due to the recognition of a trouble in the input voltage.

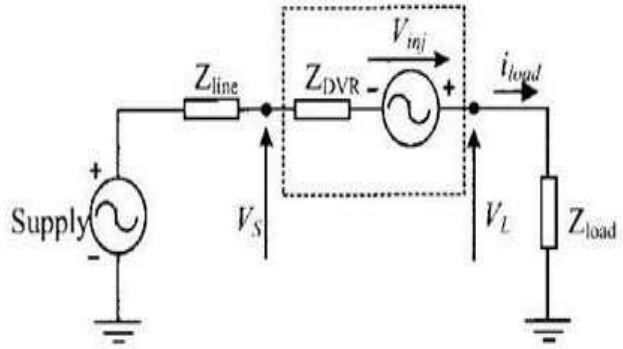

Fig.2. DVR equivalent circuit diagram

- DVR Used for Medium Voltage Level: When DVR is attached to the MV-level; it is used to protect a large consumer or a group of consumers as shown in Fig.3. When a large Dynamic voltage restorer is inserted in medium voltage level it will only increases supply impedance for a low voltage load

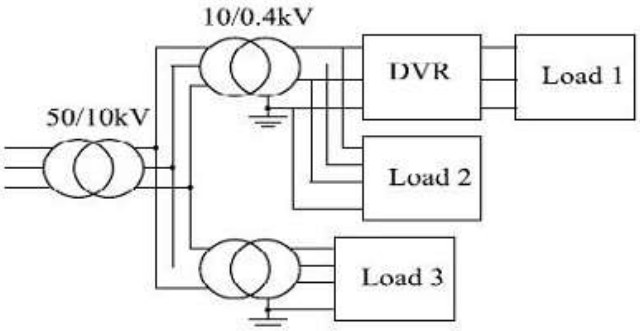

Fig.3. DVR connected to MV-level

Attaching a large DVR at MV-level has following advantages:

- The increased impedance inserted with a DVR seen by a LV load can be relative small if a large DVR is placed at the MV-level.
- It has less cost when considering costs per MVA for protection. When only one large rating DVR is located at the medium voltage level instead of small rated DVR units the total cost is also decreased.

It has few disadvantages:

- Sometimes the losses in the medium voltage DVR will be too high.
- Requires a high isolation level and the short circuit level are also high.

DVR used for low voltage level: The introduction of a DVR at the low voltage four- wire 400 V level is demonstrated in Fig.4. The increase in impedance by addition of a small rated DVR can be important for the load to be protected from voltage dips. Thereby, the percent change in the impedance can be increased by several hundred percent. It has certain advantages:

- In this the distribution transformer decreases the short circuit level and the DVR can be protected very easily.
- It can be placed by the customer domain or by the utility domain.
- The DVR can be under attack more specifically at voltage dip sensitive loads.

It has some disadvantage: After insertion of DVR, the increase in impedance is large, which may affects the short circuit level and protection of the site.

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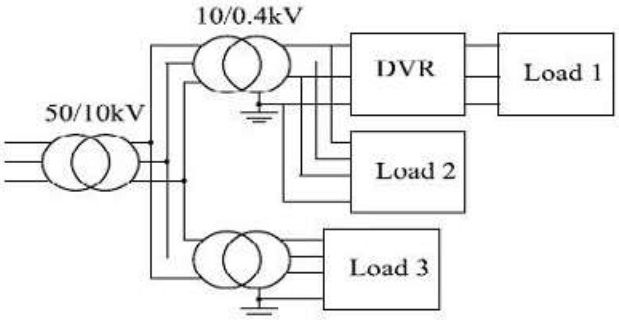


Fig.4. DVR connected to MV-level

3. HYSTERESIS VOLTAGE CONTROL

The control of dynamic voltage restorer is relates with the detection of voltage sag/dip, voltage swell, and the generation of the reference voltages for injection purpose. The sag, swell detection technique is very important task for the appropriate working of dynamic voltage restorer. There are various techniques for the detection of voltage sag, swell. Some are given below [6].

- Measuring peak values of input supply.
- Measuring of voltage components in dq frame in a vector controller.
- Applying phase locked loop to each phase.
- Applying the Fourier transform to every phase.
- Applying the wavelet transform to every phase.

A. Structure of DVR by using Hysteresis Voltage Control Technique

Following figure explains the main control diagram of dynamic voltage restorer with hysteresis voltage controller. It mainly consists of three phase IGBT inverter, Energy storage, booster transformer and the hysteresis voltage controller as shown in Fig.5. The hysteresis controller mainly requires two voltage signals, one is from supply side voltage signal and another is from booster transformer which is voltage injected by dynamic voltage restorer. The controller compares these two signals and according to these signals switching pattern is established. The hysteresis switching method is well explained in fig.6 also the design of hysteresis voltage controller in MATLAB software is given in fig. 7.

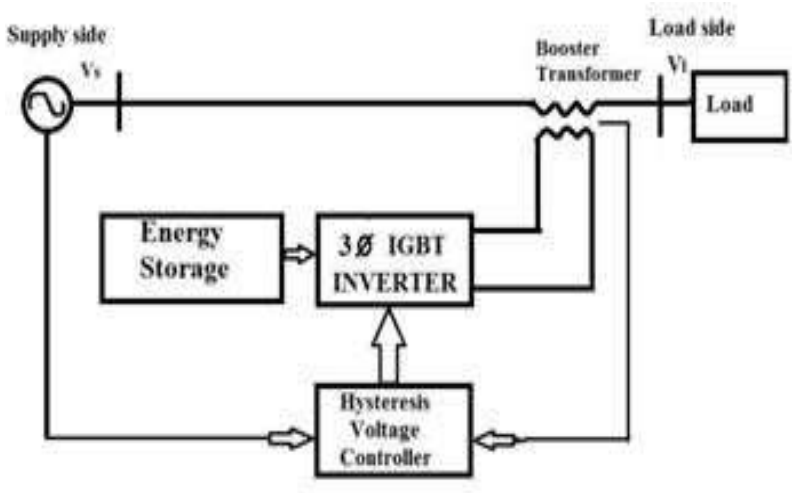


Fig 5. Structure of DVR with Hysteresis Voltage Control Technique

The control technique applied in this paper is based on voltage error and is non linear control method. It consists of a comparison between the output voltage and the tolerance limits (V_H, V_L)around the reference voltage, While the output voltage is between upper limit and lower limit , no switching occurs and when the output voltage increases to the upper limit (lower band) the output voltage is decreased(increased).

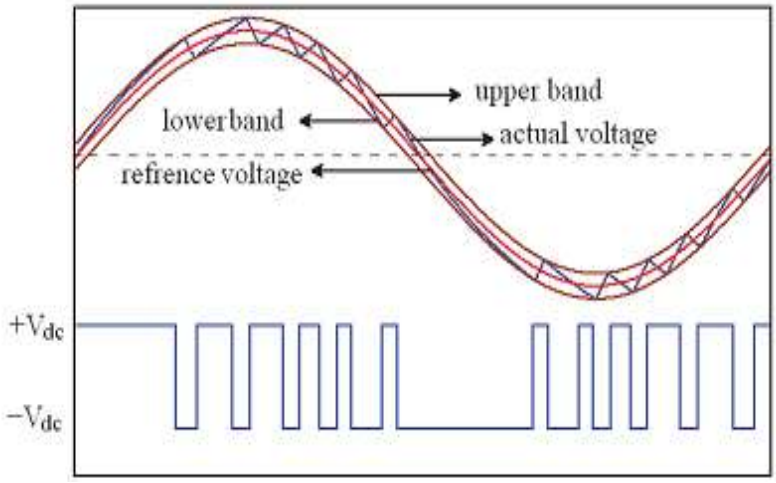


Fig 6: Hysteresis switching pattern

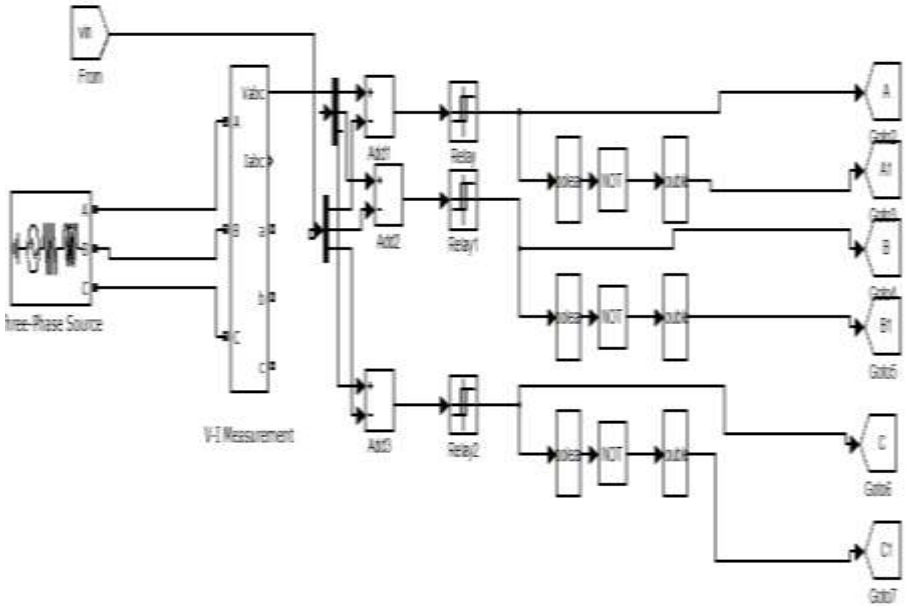
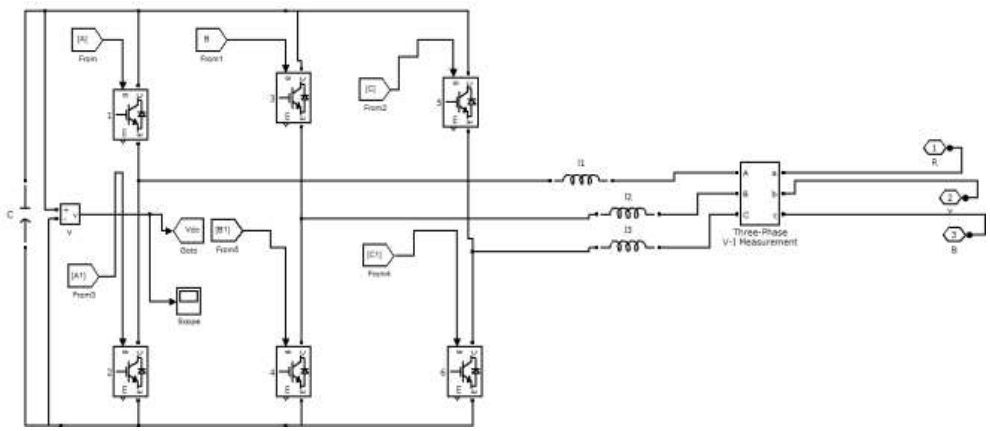


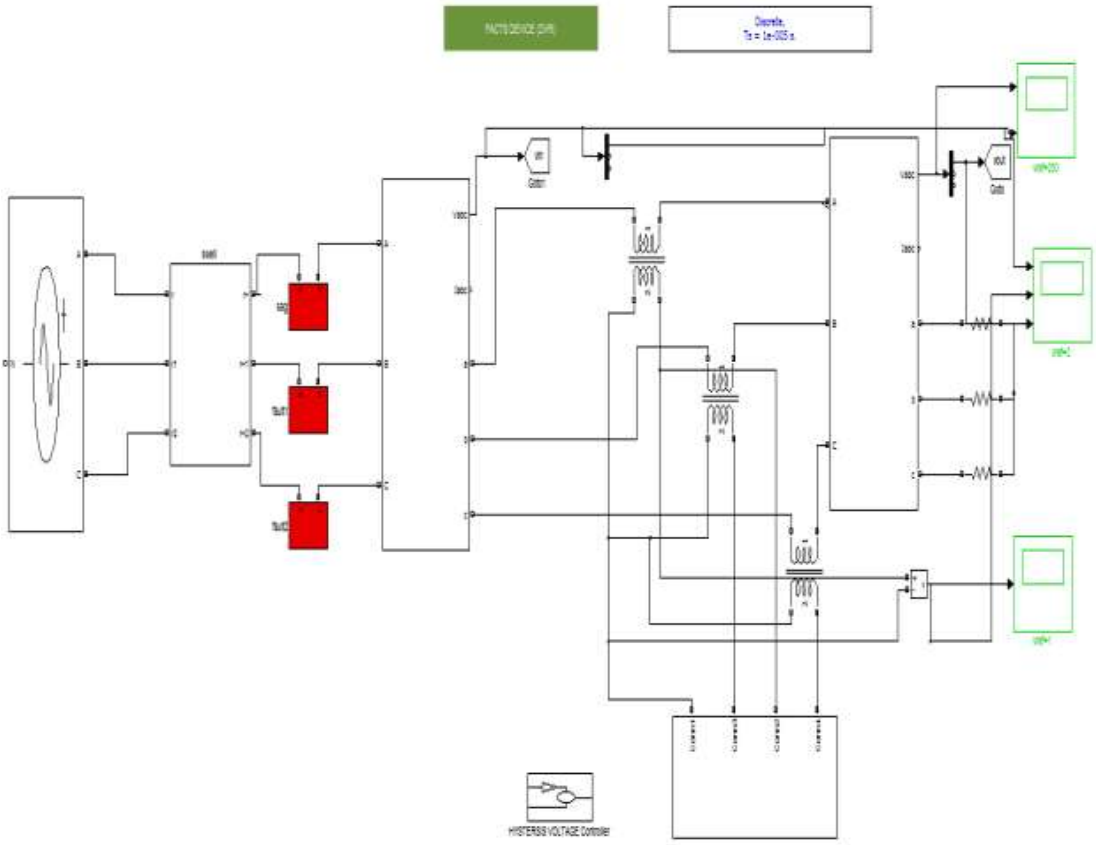
Fig.7.Hysteresis voltage controller in MATLAB.

4. SIMULATIONS AND RESULTS

4.1 Mat-lab / Simulink model of the DVR



4.2 Matlab/Simulink model of fault and Sag generation and mitigated by DVR



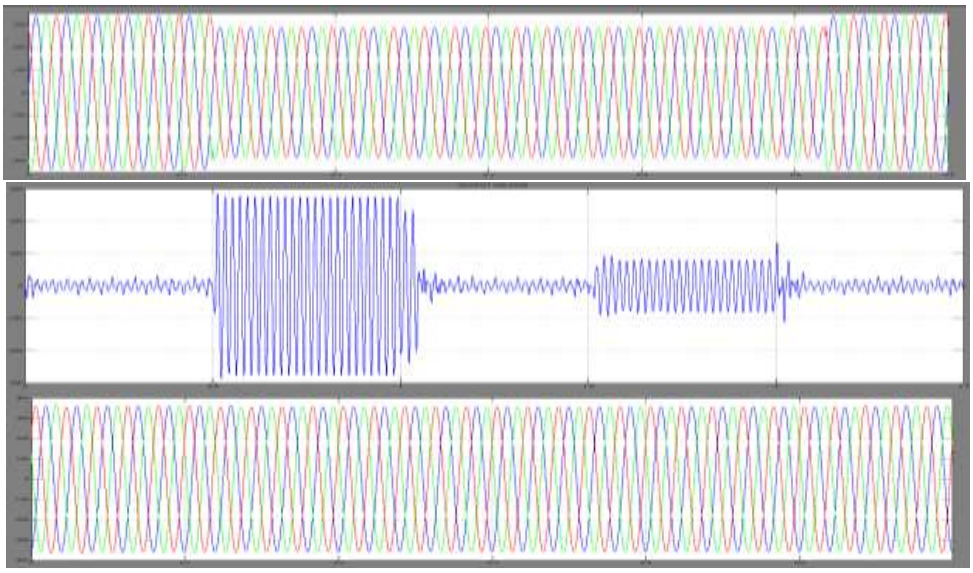


Fig.8 Simulation waveforms of source voltage, DVR voltage, load voltage

4.3 Matlab/Simulink model of fault and Swell generation and mitigated by DVR

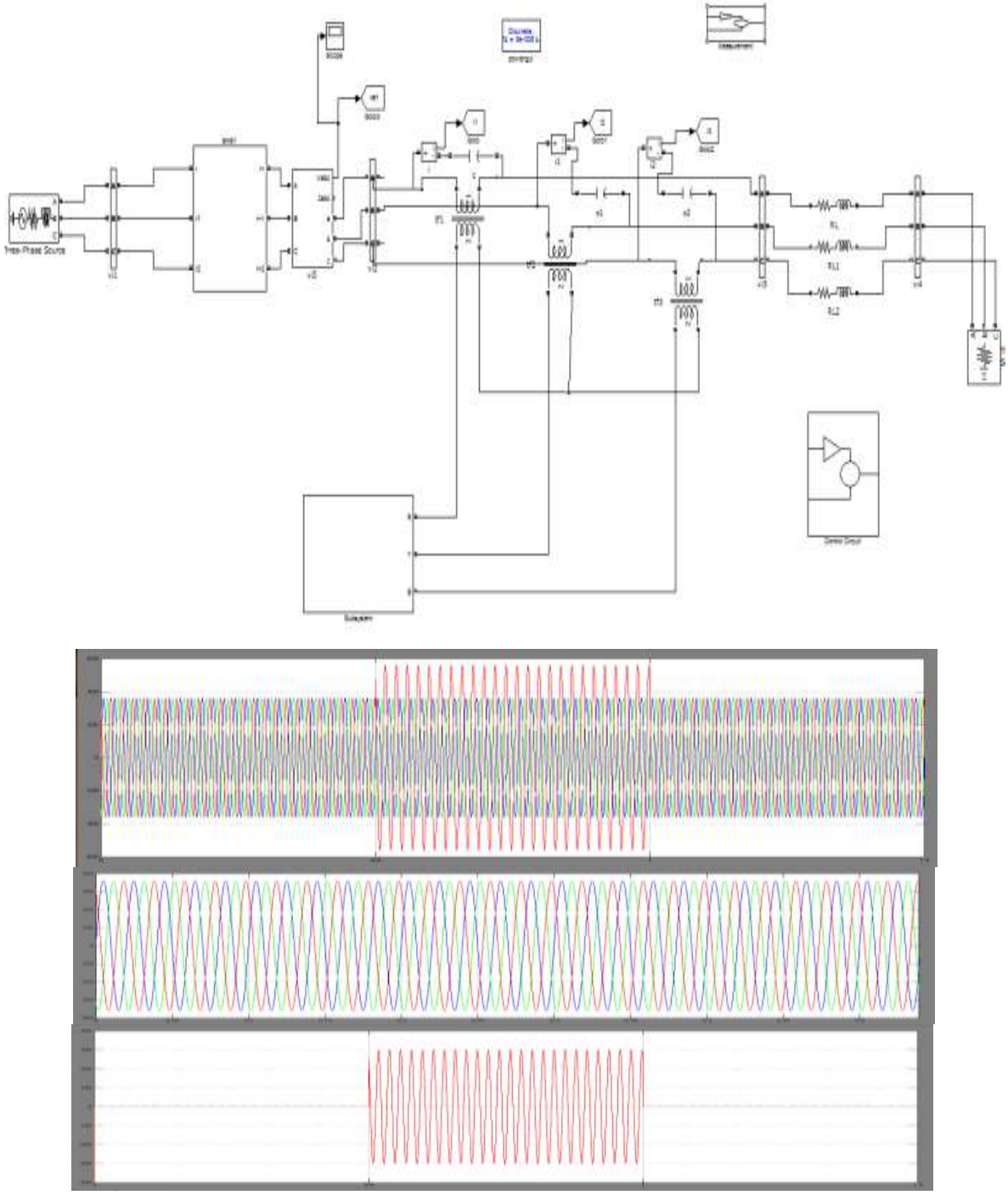


Fig.9. Simulation waveforms of source voltage, load voltage, DVR voltage

5. CONCLUSIONS

This paper has presented the power quality problems such as voltage dips, swells, distortions and harmonics. Compensation techniques of custom power electronic devices DVR was presented. The design and applications of DVR for voltage sags and comprehensive results were presented. The analysis of mitigating harmonics, DVR under hysteresis voltage controller is carried out using MATLAB Power System Block set. The results of simulation are presented and discussed. The THD and the amount of unbalance in load voltage are decreased with the application of DVR. The proposed system performs better than the traditional methods in mitigating harmonics, voltage sags and swells.

References

1. Ming Fang, Mister I. Gardiner, Andrew MacDougall M. Bollen. “Understanding Power Quality Problems, voltage sags and Interruptions.” IEEE press, 1999.
2. Ming Fang, Mister I. Gardiner, Andrew MacDougall, Granta A. Matheson, A novel series dynamic voltage restorer for distribution system, IEEE 1998 C. Sankaran, "Power quality," (CRC Press, New York, 2001)
3. C. Fitzer, M. Barnes and P. Green, “Voltage Sag Detection Technique for a Dynamic Voltage Restorer”, IEEE Trans. Industry Applications, Vol. 40(1), Jan. 2004, pp. 203 - 212.
4. Power Quality Enhancement Using Custom Power Devices by A. Ghosh and G. Ledwich. 2002. Kluwer Academic Publishers
5. S. Choi, J. Li and M. Vilathgamuwa, “A Generalized Voltage Compensation Strategy for Mitigating the Impacts of Voltage Sags/Swells”, IEEE Trans. Power Delivery, Vol. 20(3),
6. C. Meyer, C. Romaus and R. De Doncker, “Optimized Control Strategy for a Medium-Voltage DVR”, IEEE Trans. Power Electronics, Nov. 2008, pp. 2746-2754.
7. Nielsen, Newman, H. Nielsen, and F. Blaabjerg, “Control and testing of a dynamic voltage restorer (DVR) at medium voltage level,” IEEE Trans. Power Electronics. vol. 19, no. 3, pp. 806–813, May 2004.
8. J. G. Nielsen, “Design and Control of a Dynamic Voltage Restorer,” Ph.D. dissertation, Institute of Energy Technology, Aalborg Univ., Aalborg, Denmark, 2002.
9. Boonchiam P, and Mithulananthan N, “Understanding of Dynamic Voltage Restorers through MATLAB Simulation”. Thammasat Int. J. Sc. Tech., Vol. 11, No. 3, July-Sept 2006.
10. Yusuf K: “Industrial power quality problems Electricity Distribution. IEEE Conf. Pub1 No. 482, Vol: 2, 18–21 June 2001 Pages: 5 pp. vo1.2. Fawzi AL Jowder, “Modeling and Simulation of Dynamic Voltage Restorer (DVR) Based on Hysteresis Voltage Control” The 33rd Annual Conference of the IEEE Industrial Electronics Society (IECON) Nov. 5-8, 2007, Taipei, Taiwan.