ISSN No: 2348-4845
International Journal & Magazine of Engineering, Technology, Management and Research
A Peer Reviewed Open Access International Journal

Mitigation of Fault Currents in Unbalanced Grid System by DVR


Sreelatha
MTech(EPS)
Department of EEE,
Tudi Narasimha Reddy Institute of Technology & Science, Hyderabad.


Dr. Samalla Krishna
Professor
Department of ECE,
Tudi Narasimha Reddy Institute of Technology & Science, Hyderabad.


Ms. Katkuri Laxmi Chaitnaya
Assistant Professor
Department of EEE,
Tudi Narasimha Reddy Institute of Technology & Science, Hyderabad.

Abstract: ***Power quality problem is an occurrence manifested as a result nonstandard voltage, current or frequency that failures. The voltage sag is the major power quality problem. To solve that type of problem, custom power devices are used. To minimize this problem custom power devises are used such as unified power quality conditioner (UPQC), distribution static compensator (D-STATCOM) and dynamic voltage restorer (DVR). This paper gives investigation on DVR which having low cost, small in size and fast dynamic response to the disturbance. Fast least error squares digital filters are used to estimate the magnitude and phase of the measured voltages and effectively reduce the impacts of noise, harmonics, and disturbances on the estimated phasor parameters, and this enables effective fault current interrupting even under arcing fault conditions.***

Key words: ***dynamic voltage restorer (DVR), voltage sag, power injected, low voltage, custom device.***

I. INTRODUCTION

High power supply is needed, because due to failures such disturbances usually have a high impact on production costs. One approach is to use Dynamic Voltage Restorers with energy storage. The DVR is a power electronics device that is able to compensate voltage sags on critical loads dynamically. Dynamic voltage restorer injects an appropriate voltage waveform, and ensures constant load voltage. The Dynamic Voltage Restorer (DVR) with the lead acid battery is an attractive way to provide excellent dynamic voltage compensation capability as well as being economical when compared to shunt-connected devices. The DVR is a custom power device that is connected in series with the distribution system. The DVR employs IGBTs to maintain the voltage applied to the load by injecting single-phase output voltages whose magnitude, phase and frequency can be controlled.

The basic function of DVR is to inject dynamically voltage required, VDVR to compensate sagging occurrence. Generally, the operation of DVR can be categorized into two modes; standby mode and injection mode. The DVR is turn into injection mode as soon as sagging is detected. VDVR is injected in series with load with required magnitude and phase of their desired waveform.

Distribution system and a load are linked to series transformer. The basic idea of the DVR is to inject a controlled voltage generated by a forced commuted converter in a series by injecting transformer. A sinusoidal PWM technique regulates the voltage by means of DC to AC inverter. The dual dynamic voltage restorer it is series to series connected devices and it is the new method of device control. In this connection of devices are also similar to upfc device.

The Dual dynamic voltage restorer injects only a low voltage to compensate for the voltage drop of the transformer injection and power quality losses. When voltage sag occurs in the distribution system, the DVR controller calculates and compensates the voltage required output voltage to the load by injecting a controlled voltage with a certain magnitude and phase angle into the distribution system to the critical load. Note that the DVR capable of generating or absorbing reactive power but the active power injection of the device must be provided by an external energy source. The DVR response time is very short and is limited by the power electronics devices, and which is much less than some of the traditional methods of voltage correction such as tap-changing transformers.

There are various types of voltage sag mitigation equipment that available nowadays such as Uninterrupted Power Supply (UPS), flywheel, and the flexible ac technology (FACTS) devices which have been widely used in the power system due to reliability.

The most FACTS devices that have been improving the performance of power quality are Dynamic Voltage Restorer (DVR) also known as custom power devices. DVR which consists of the injection transformer, filter unit, PWM inverter, and energy storage issued to mitigate the voltage sag problem in the power distribution system. Control unit is the heart of the DVR where it main function is to detect the presence of voltage sags in the system, calculating the required compensating voltage for the DVR and generate the reference voltage for PWM generator to trigger on the PWM inverter. The components of control system unit are the dq0- transformation, Phase-lock-loop (PLL) and the PI or FL Controller. PI Controller is a feedback controller which drives the plant to be controlled with a weighted sum of the error (difference between output and desired set-point) and the integral of that value.

II. DYNAMIC VOLTAGE RESTORER

SPWM or Sinusoidal Pulse Width Modulation is widely used in power electronics to digitize the power so that a sequence of voltage pulses can be generated by power switches on and off. The PWM inverter has been the main choice in power electronic for decades, because of its circuit simplicity and difficulty. SPWM techniques are characterized by constant amplitude pulses with different duty cycle. The width of the pulses are modulating in order to obtain inverter output voltage control and to reduce its harmonic values. The most common method in motor control and inverter application are used in SPWM to generate the signal, triangle wave as a carrier signal and to compare with the sinusoidal wave, whose frequency is the desired frequency. The use of the Atmel microcontroller brings flexibility to change the real-time control algorithms. It will reduce the overall cost and has a compact size of control circuit for the single phase full bridge inverter.

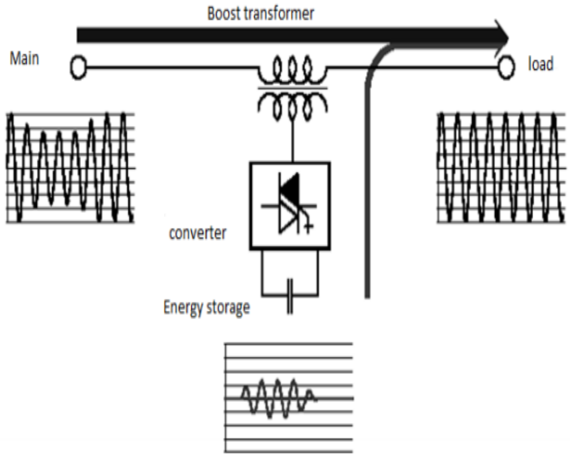


Fig.1: Schematic diagram of a DVR with a line-side harmonic filter.

The inverter circuit in DVR is responsible for generation of the compensating voltage. Hence the control of the inverter will directly affect the performance of the DVR. The inverter used in the proposed DVR is a three phase six pulse inverter. The thyristor used in the inverter circuit are chosen to be Insulated Gate Bipolar Transistors (IGBT) for their fast response and speed operation. Sinusoidal Pulse Width Modulation (SPWM) technique used the inverter for controlling the modulation index hence controlling the output voltage of the inverter. In SPWM, a sinusoidal reference signal of supply frequency (i.e. 50 Hz) is compared with a high

ISSN No: 2348-4845
International Journal & Magazine of Engineering, Technology, Management and Research
A Peer Reviewed Open Access International Journal

frequency triangular carrier waveform (i.e. 1080 Hz for this study).

When the sinusoidal reference signal is greater than the triangular carrier wave, a batch of three IGBT switches out of the six are turned on and the counter switches are turned off and when the reference sinusoidal signal is smaller than the triangular carrier waveform in magnitude then the second batch of three IGBT switches are turned on and the first batch of switches are turned off. The magnitude of the sinusoidal reference signal determines the modulation index of the PWM signal generator which is dependent upon the error signal. The magnitude of the sinusoidal reference signal is controlled by the PI based feedback controller which adjusts the magnitude according to the error magnitude and hence control the modulation index. The proposed DVR utilizes large capacitor banks for storing dc energy. The capacitor banks are used to charge the rectified supply line voltage. DC voltage from alternative supply sources can also be utilized with the proposed configuration of DVR.

III. CONTROL STRATEGY

The adopted DVR converter is comprised of three independent H-bridge VSCs that are connected to a common dc-link capacitor. These VSCs are series connected to the supply grid, each through a single-phase transformer. The proposed FCI control system consists of three independent and identical controller's one for each single-phase VSC of the DVR.

The FCI function requires a phasor parameter estimator (digital filter) which attenuates the harmonic contents of the measured signal. To attenuate all harmonics, the filter must have a full-cycle data window length which leads to one cycle delay in the DVR response.The designed LES filters utilize a data window length of 50 samples at the sampling rate of 10 kHz and, hence, estimate the voltage phasor parameters in 5 ms. the frequency response of the LES filters and indicates significant attenuation of voltage noise, harmonics, and distortions at frequencies higher than 200 Hz and lower than 50 Hz. Reference demonstrates the effectiveness of this filter in attenuating the noise, harmonics, and distortions for the sag compensation mode of operation as well.

The next section shows that this filter also performs satisfactorily in the FCI operation mode, even under arcing fault conditions where the measured voltage and current signals are highly distorted.

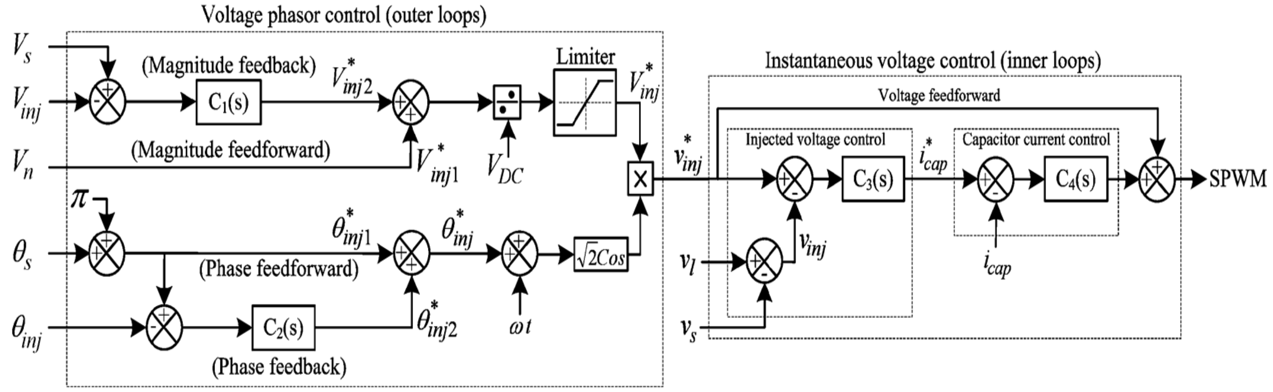


Fig 2: the DVR control system in FCI mode.

Voltage Phasor Control System:

In the FCI operation mode, the required injected voltage phasor is equal to the source voltage phasor, but in phase opposition. Performance of the voltage phasor control, in terms of transient response, speed, and steady-state error, is enhanced by independent control of voltage magnitude and phase, and incorporating feedforward signals to the feedback control system.

Instantaneous Voltage-Control System

ISSN No: 2348-4845
International Journal & Magazine of Engineering, Technology, Management and Research
A Peer Reviewed Open Access International Journal

Under ideal conditions, voltage sag can be effectively compensated if the output of the phasor-based controller is directly fed to the sinusoidal pulse-width modulation (SPWM) unit. However, resonances of the harmonic filter cannot be eliminated under such conditions. Therefore, to improve the stability and dynamic response of the DVR, an instantaneous injected voltage controller and a harmonic filter capacitor current controller are used to attenuate resonances. The generated reference signal for the injected voltage is compared with the measured injected voltage and the error is fed to the voltage controller. As shown in Fig. 2, the output of the voltage controller is the reference signal for the filter capacitor current control loop. It is compared with the measured capacitor current, and the error is fed to the current controller.

IV. SIMULATION RESULTS

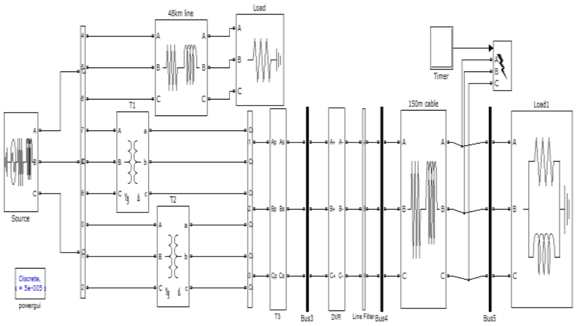


Fig 3: simulation circuit DVR integrated to grid

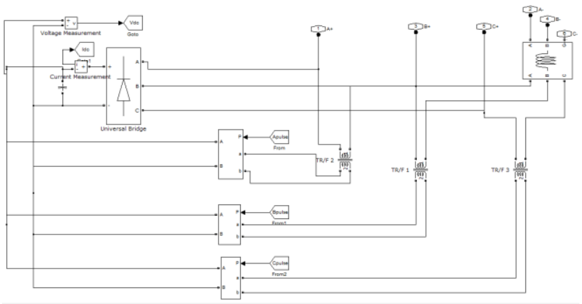


Fig 4: simulation design of DVR

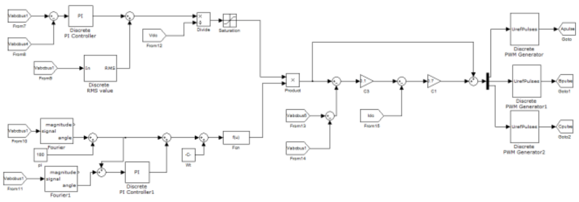


Fig 5: control strategy

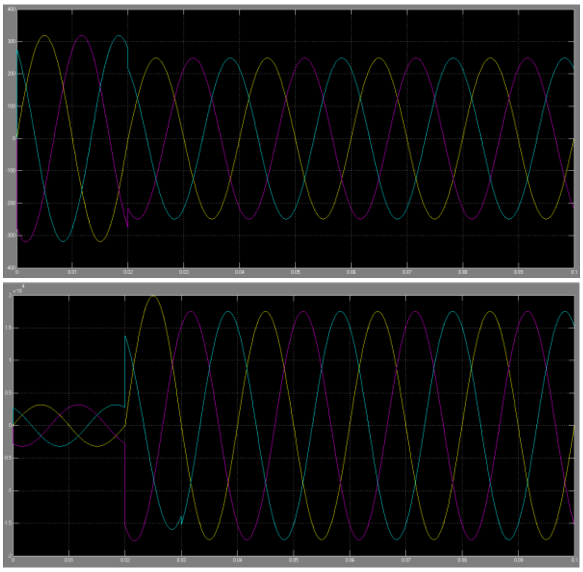
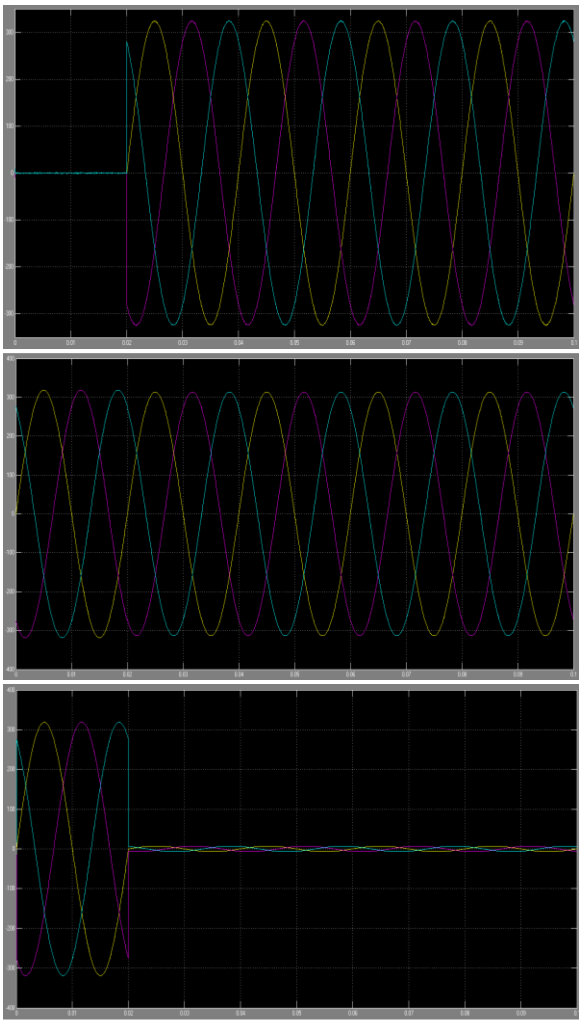


Fig 6: Voltages at bus3 and Fault currents, during downstream three-phase fault when the DVR is inactive (bypassed).



ISSN No: 2348-4845
International Journal & Magazine of Engineering, Technology, Management and Research
A Peer Reviewed Open Access International Journal

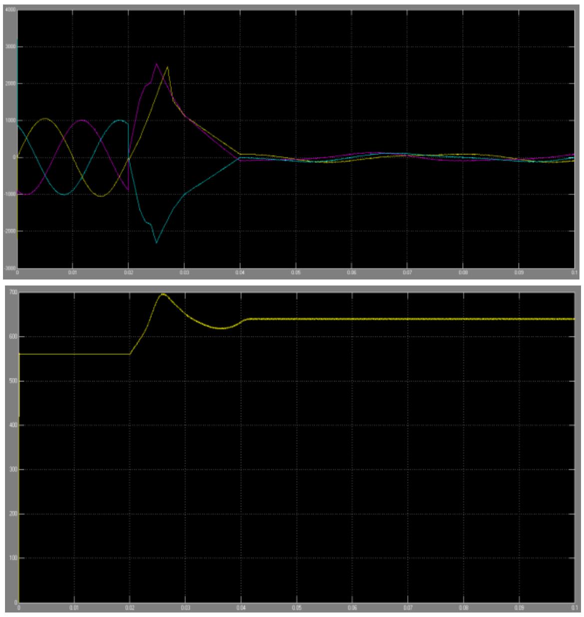


Fig 7: Injected voltages, Source voltages, Load voltages, Line currents, DC-link voltage, during the three-phase downstream fault.

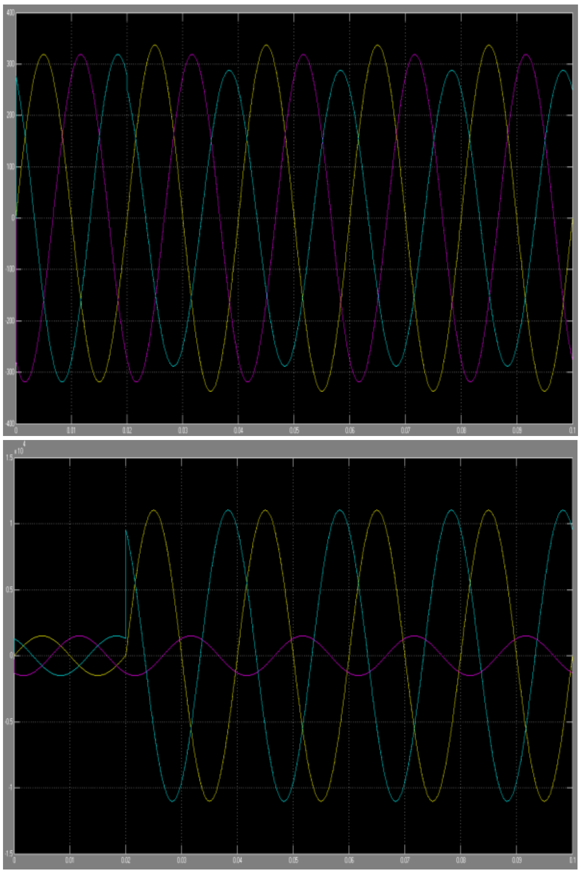


Fig. 8: (a) Voltages at bus3, (b) Fault currents, during downstream phase-to-phasefault when the DVR is inactive (bypassed).

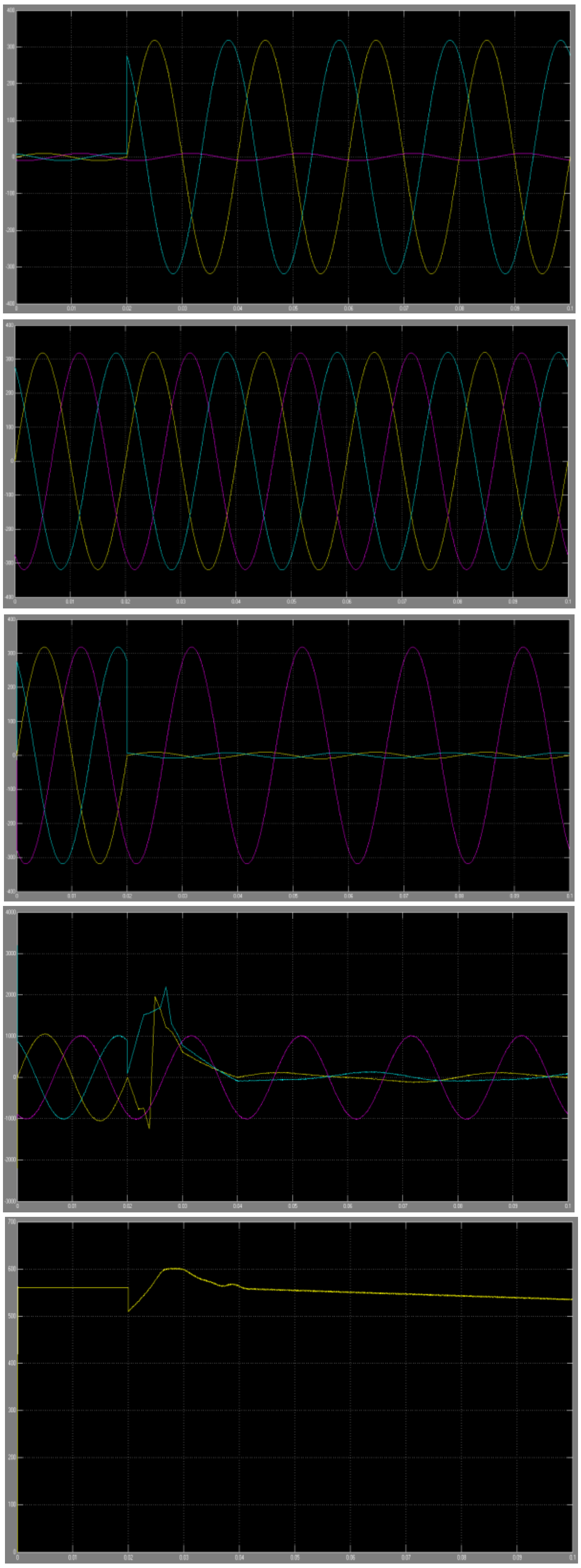


Fig. 9: (a) Injected voltages. (b) Source voltages. (c) Load voltages. (d) Linecurrents. (e) DC-link voltage, during the phase-to-phase downstream fault.

ISSN No: 2348-4845
International Journal & Magazine of Engineering, Technology, Management and Research
A Peer Reviewed Open Access International Journal

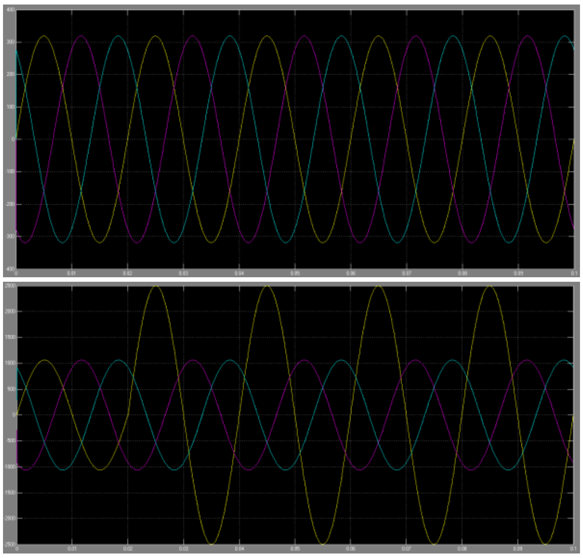
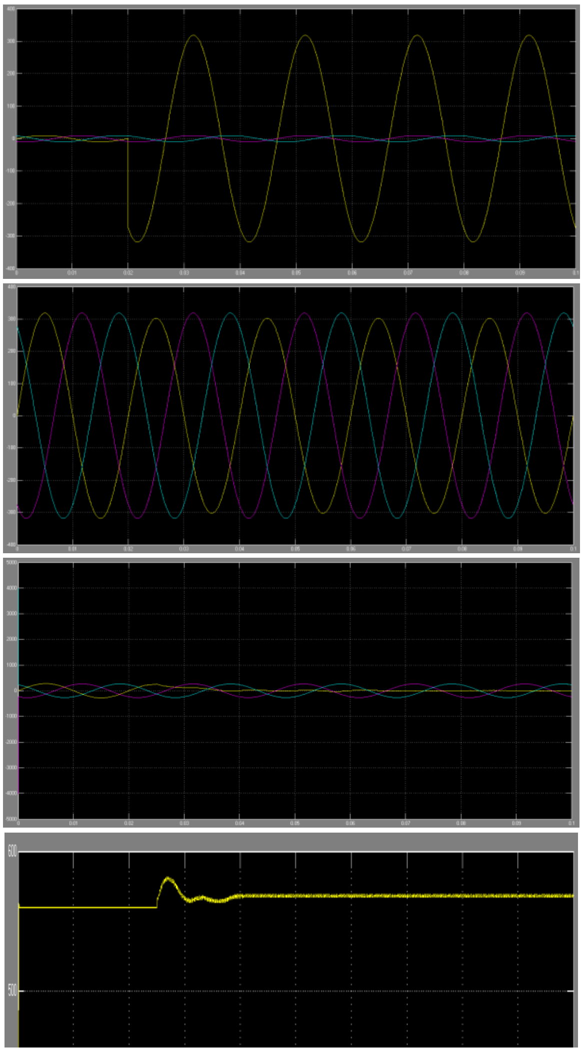


Fig. 10. (a) Voltages at bus3. (b) Fault currents, during the downstream singlephase-to-ground fault when the DVR is inactive (bypassed).



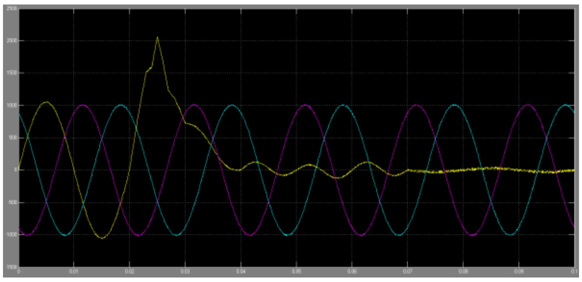


Fig 11: (a) Injected voltages. (b) Source voltages. (c) Load voltages. (d) Linecurrents. (e) DC-link voltage, during the single-phase-to-ground downstreamfault.

V. CONCLUSION

The proposed multiloop control system provides a desirabletransient response and steady-state performance and effectivelydamps the potential resonant oscillations caused by the DVR LC harmonic filter; the proposed control system detects and effectively interruptsthe various downstream fault currents within two cycles(of 50 Hz);the proposed fault current interruption strategy limits theDVR dc-link voltage rise, caused by active power absorption,to less than 15% and enables the DVR to restorethe PCC voltage without interruption; in addition, it interruptsthe downstream fault currents even under low dc-linkvoltage conditions. The proposed control system also performs satisfactorilyunder downstream arcing fault conditions.

REFERENCES

[1] N. G. Hingorani, “Introducing custom power,” IEEE Spectr., vol. 32,no. 6, pp. 41–48, Jun. 1995.

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

[3] G. J. Li, X. P. Zhang, S. S. Choi, T. T. Lie, and Y. Z. Sun, “Controlstrategy for dynamic voltage restorers to achieve minimum powerinjection without introducing sudden phase shift,” Inst. Eng. Technol.Gen. Transm. Distrib., vol. 1, no. 5, pp. 847–853, 2007.

[4] S. S. Choi, B. H. Li, and D. M. Vilathgamuwa, “Design and analysisof the inverter-side filter used in

the dynamic voltage restorer," IEEETrans. Power Del., vol. 17, no. 3, pp. 857–864, Jul. 2002.
[5] B. H. Li, S. S. Choi, and D. M. Vilathgamuwa, "Design considerationson the line-side filter used in the dynamic voltage restorer," Proc. Inst.Elect. Eng., Gen. Transm. Distrib., vol. 148, no. 1, pp. 1–7, Jan. 2001.
[6] S. S. Choi, B. H. Li, and D. M. Vilathgamuwa, "Dynamic voltagerestoration with minimumenergy injection," IEEE Trans. Power. Syst.,vol. 15, no. 1, pp. 51–57, Feb. 2000.
[7] Y. W. Li, D.M. Vilathgamuwa, P. C. Loh, and F. Blaabjerg, "A dualfunctionalmedium voltage level DVR to limit downstream fault currents,"
IEEE Trans. Power. Electron., vol. 22, no. 4, pp. 1330–1340,Jul. 2007.
[8] Y. W. Li, D. M. Vilathgamuwa, F. Blaabjerg, and P. C. Loh, "A Robustcontrol scheme for medium-voltage-level DVR implementation,"IEEE Trans. Ind. Electron., vol. 54, no. 4, pp. 2249–2261, Aug. 2007.
[9] S. S. Choi, T. X. Wang, and D. M. Vilathgamuwa, "A series compensatorwith fault current limiting function," IEEE Trans. Power Del.,vol. 20, no. 3, pp. 2248–2256, Jul. 2005.
[10] B. Delfino, F. Fornari, and R. Procopio, "An effective SSC controlscheme for voltage sag compensation," IEEE Trans. Power Del., vol.20, no. 3, pp. 2100–2107, Jul. 2005.