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Design Considerations of a Fault Current Limiting Dynamic Voltage Restorer (FCL-DVR)

N. Narasimhulu[1], A. Pravallika Rani[2], Dr. R. Ramachandra[3]

[1]*Associate Professor and Head, Department of EEE, SKD College of Engineering, Gooty, AP, India*
[2]*PG Student, SKD College of Engineering, Gooty, AP, India*
[3]*Principal, SKD College of Engineering, Gooty, AP, India*

Abstract: In this project, a concept of fault current limiting dynamic voltage restorer (FCL-DVR) is proposed. It should be noted that only one additional crowbar bidirectional thyristor switch is added across the output terminals of each phase of the conventional DVR, greatly simplifying its implementation. Furthermore, the FCL-DVR can maintain the same power rating as the conventional DVR without FCL function. The proposed work can be carried using Matlab/Simulink..

Keywords: DVR, Voltage Sag, Crow Bar thyrisitor

I. Introduction

Voltage sags can be defined as a short reduction in voltage magnitude for durations of time, and is the most important and commonly occurring power quality issue of our days. Voltage sags also known as voltage dips. It can easily disrupt the operation of sensitive loads. Among the power quality problems voltage sags are the most important and common of the system. Higher capacity of the power grid results in higher fault currents. Among the numerous faults occurring in power distribution systems, the short-circuit fault is, probably, the most destructive one [1]. There are several traditional approaches to manage the fault current in distribution systems [2].

A fuse can open in less than half a cycle at current levels, which are well under the peak available fault current [3], [4]. However, CBs with high-current interrupting capabilities are bulky and expensive electromechanical systems. CBs require maintenance and calibration and have a limited lifetime and number of cycles [5].

A DVR is a solid state power electronics switching device which comprises of either GTO or IGBT, a capacitor bank as energy storage device and injection transformers. The dynamic voltage restorer (DVR) is used to deal with the voltage dip. It is designed to compensate line transients by inserting a voltage in series with the distribution supply mains. The magnitude and phase of the inserted voltage can compensate the voltage deviation caused by the upstream distribution network disturbance. The Dynamic Voltage Restorer (DVR), it provides series compensation by voltage injection for power system sag and swell. It can supply or absorb both real and reactive power to compensate the disturbances. DVR is primarily for use at the distribution level. Out of the various approaches that have been have been proposed to limit the cost causes by voltage sag, dynamic voltage restorer (DVR) is one of the best methods to address voltage sag problems.

II. Dynamic Voltage Restorer

The basic idea of DVR is that by means of an injecting transformer a control voltage is generated by a forced commuted convertor which is in series to the bus voltage. A regulated DC voltage source is provided by a DC capacitor bank which acts an energy storage device. Under normal operating conditions when there is no voltage sags, DVR provides very less magnitude of voltage to compensate for the voltage drop of transformer and device losses. But when there is a voltage sag in distribution system, DVR will generate a required controlled voltage of high magnitude and desired phase angle which ensures that load voltage is uninterrupted and is maintained. In this case the capacitor will be discharged to keep the load supply constant.

The response time of DVR is very short and is limited by the power electronics devices and the voltage sag detection time. The schematic diagram Schematic diagram of DVR is shown in Figure 1.

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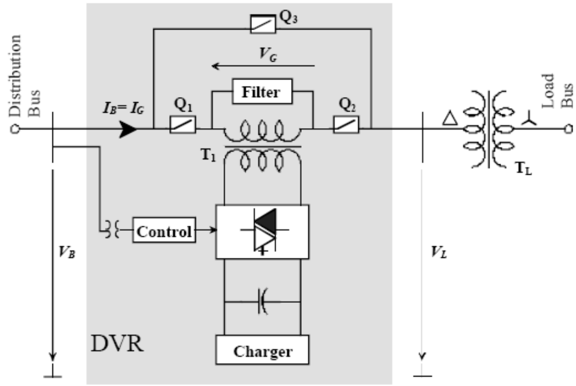

Figure1: Schematic diagram of DVR

Generally Pulse-Width Modulated Voltage Source Inverter (PWMVSI) is used. Thus a VSI with a low voltage rating is sufficient. To convert the PWM inverted pulse waveform into a sinusoidal waveform, low pass passive filters are used. In order to achieve this it is necessary to eliminate the higher order harmonic components during DC to AC conversion in Voltage Source Inverter which will also distort the compensated output voltage. The difference between the pre sag voltage and the sag voltage is injected by the DVR by supplying the real power from the energy storage element and the reactive power. The DVR injects the difference between the pre-sag and the sag voltage, by supplying the real power requirement from the energy storage device together with the reactive power. During the normal operation as there is no sag, DVR will not supply any voltage to the load. It will be in a standby mode or it operates in the self charging mode if the energy storage device is fully charged. The energy storage device can be charged either from the power supply itself or from a different source.
In this case we have seen before that a bypass switch (crossbar switch) will be activated and it will bypass the inverter circuit in order to protect the electronic components of the inverter.

III. DVR Compensation Strategies

One of the most important power quality problems facing industrial customers is the voltage sag. The main source of voltage sags is short circuit faults in the grid system.

Different control strategies have been evaluated in order to control the DVR. The most commonly used method is to put the DVR voltage in phase with the supply voltage, regardless of the actual phase angle of the load current. An undisturbed load voltage requires this method, but it may lead to a fast drain of the energy storage unit. Energy optimized control has been adapted to save energy and fully utilize the energy storage capacity.

Symmetrical voltage dip is ideally characterized by the dip duration, magnitude reduction and a phase jump. A control strategy for voltage dips with phase jump should be included in order to be able to compensate for this particular type of symmetrical voltage dip. The DVR can be controlled by a number ways to improve certain parameters. It is first assumed, that the DVR is only active during the voltage dip.

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The load voltage dependency is particular important if the DVR is not able to restore the load voltages. Then the absorbed current or power will change according to the type of load connected. The different types of load must be handled by the DVR and a robust performance is important. With a constant power load it can even be considered to restore the load voltage to a higher voltage level to reduce the load current.

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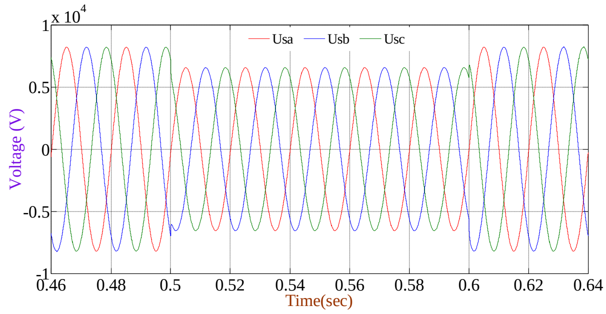
IV. Simulation Result Analysis

This section presents detailed simulation results of the proposed control system. Simulation is carried out to verify the validity of the proposed topology and design methodology. The supply voltage is set at 10 kV with a 1 MW resistive load. The parameters are summarized in Table 1.

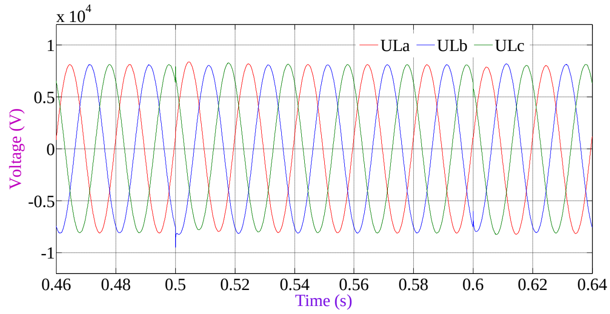
Table 1: Parameters of simulation

Parameters	Values
Capacity	132kVA
DC link voltage	2*400V
LC filter of series converter	0.35mH, 33μF
Series transformer ratio	8:1
DC link capacitance	11 μF
Shunt transformer ratio	22

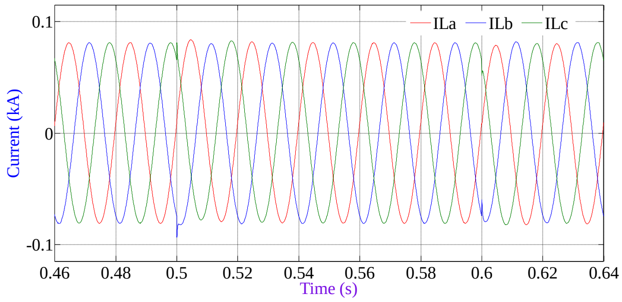
As shown in Figure 2, voltage sag happens between 0.5 and 0.6 s with a depth of 20%.



(a) Source Voltage



(b) Load Voltage



(c) Load Current

Figure 2: Waveforms of FCL-DVR during voltage fluctuation event

In Figure 3, three phase unbalance occurs between 0.5 and 0.6 s. The voltage of phase-A is not changed; the voltage of phase-B drops; the voltage of phase-C rise; and phase angle keeps invariant. The FCL-DVR put into operation at 0.5 s.

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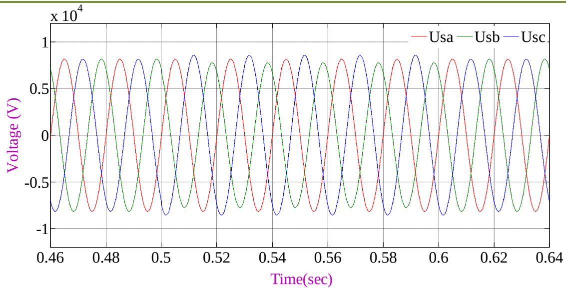

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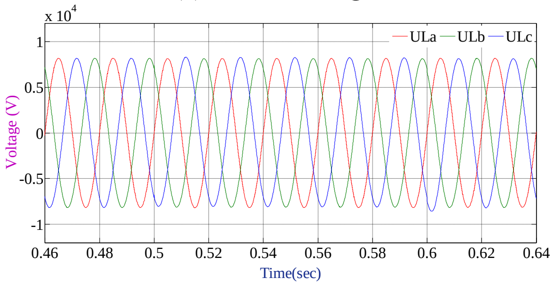
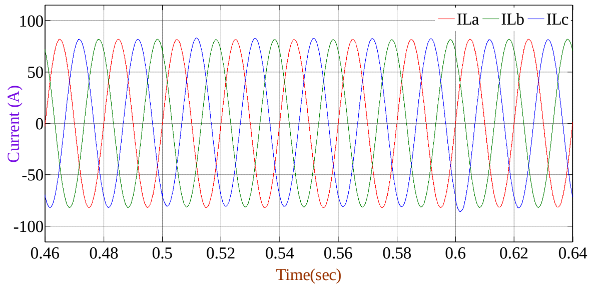
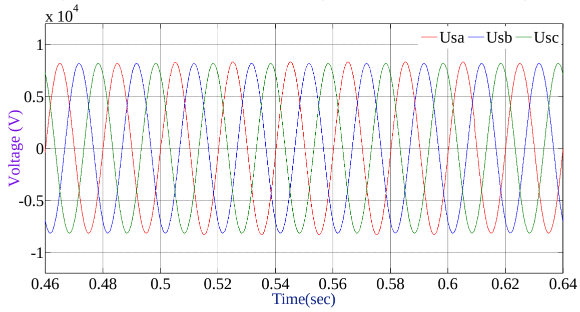


(b) Load Voltage

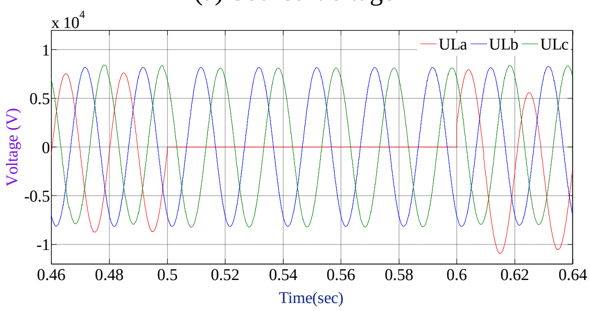


(c) Load Current

Figure 3: FCL-DVR during unbalanced voltage



(a) Source Voltage



(b) Load Voltage

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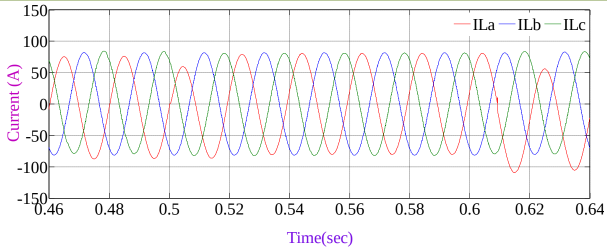
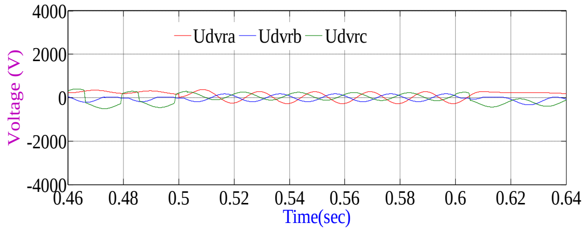
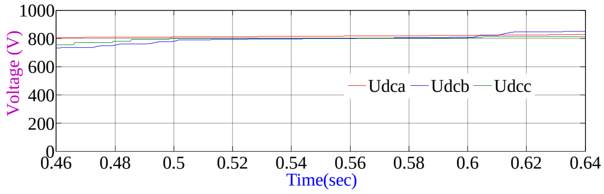


(c) Load Current



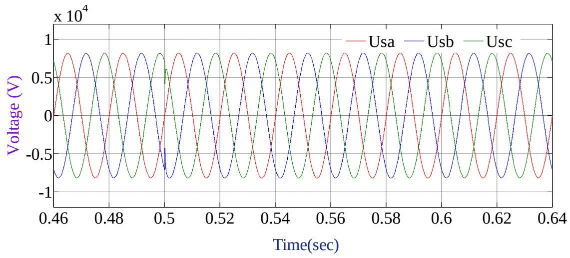
(d) DVR Voltage



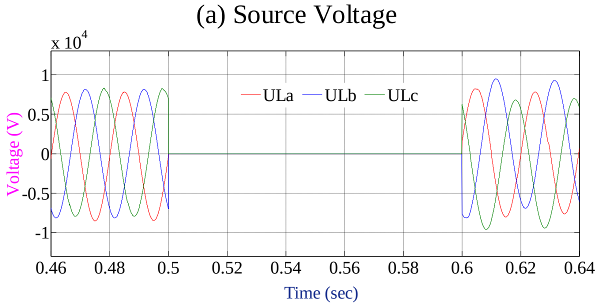
(e) DC Link Voltage

Figure 4: FCL-DVR during single phase to ground fault

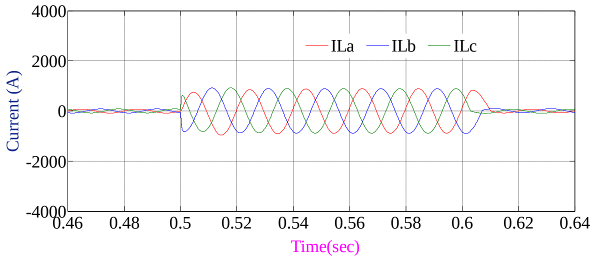
In Figure 4, single phase (phase A) to ground fault occurs at 0.5 s, and disappears at 0.6 s.



(a) Source Voltage



(b) Load Voltage



(c) Load Current

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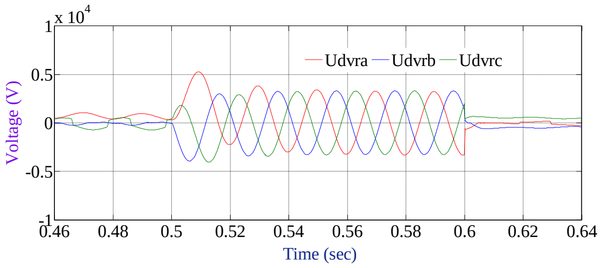
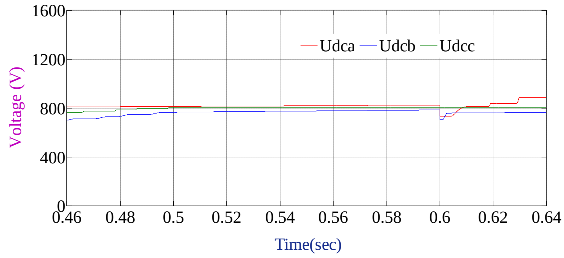


(d) DVR Voltage



(e) DC Link Voltage

Figure 5: Waveforms of FCL-DVR during three-phase to ground short circuit fault

In Figure 5, three phases to ground fault occurs between 0.5 and 0.6 s. Similarly as phase-to-phase short circuit fault and two-phase to ground fault, the FCL-DVR can immediately switch to fault current limiting mode while the fault happens, and also can switch to voltage compensation mode while the fault disappears.

V. Conclusion

In this paper, the FCL-DVR concept is proposed to deal with both voltage fluctuation and short current faults. The proposed FCL-DVR can compensate voltage fluctuation and limit fault current. The performance of the proposed methodology is verified through simulation analysis.

References

[1]. A. Prasai and D. M. Divan, "Zero-energy sag corrector with reduced device count," *IEEE Trans. Power Electron.*, vol. 24, no. 6, pp.1646–1653, Jun. 2009.

[2]. J. Suma and M. K. Mishra, "Instantaneous symmetrical component theory based algorithm for characterization of three phase distorted and unbalanced voltage sags," in *Proc. IEEE Int. Conf. Ind. Technol.*, Feb. 2013, pp. 845–850.

[3]. A. Ghosh and G. Ledwich, *Power Quality Enhancement Using Custom Power Devices*. Norwell, MA, USA: Kluwer, 2002.

[4]. M. Bollen, "Algorithms for characterizing measured three-phase unbalanced voltage dips," *IEEE Trans, Power Del.*, vol. 18, no. 3, pp.937–944, Jul. 2003.

[5]. 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.

[6]. *IEEE Recommended Practice for Emergency and Standby Power Systems for Industrial and Commercial Applications*, IEEE Standard 446-1995, Jul. 3, 1996.

[7]. P.T. Nguyen, Tapan K. Saha, "Dynamic Voltage Restorer against balanced and unbalanced voltage sags: Modelling and simulation". IEEE transactions on Power Delivery, 2004, pg1-6.

[8]. G. Ramtharan, S.G. Abeyratne, A.Atputharajah,"Constant frequency control of an active power filter", National Science Foundation, Sri Lanka, 2006,34(1)pg.21-28.

[9]. Kasuni Perera, Arualpalam Atputharajah, Sanath Alahakoon, Daniel Salomonsson "Automated Control Technique for a Single Phase Dynamic Voltage Restorer" December 15-17, 2006, Colombo, Sri-Lanka.

[10]. W. Raithmayr, P. Daehler, M. Eichler, G. Lochner, EricJohn, Kevin Chan "Customer Reliability Improvement with a DVR or a DUPS" ABB Industries AG.

[11]. Lessons in Electric Circuits – Volume II Date: 20/03/2010 http://ftp.ibiblio.org/kuphaldt/electricCircuits/AC/AC_10.html.

Author Details

Mr. N. Narasimhulu has completed his professional career of education in B.Tech (EEE) from JNTU Hyderabad in the year 2003. He obtained M.Tech degree from JNTU, HYDERABAD, in year 2008. He is pursuing Ph. D in the area of power system in JNTU *Anantapuramu*. He has worked as *Assistant Professor* from 2003-2008 and at present working as an Associate Professor and Head of the EEE Department in *Srikrishna Devaraya Engineering College, Gooty of Anantapuramu* district (AP). He is a life member of ISTE, FIE, IEEE. His areas of interests include Electrical Power Systems, Electrical Circuits and Control Systems

A. Pravallika Rani completed her professional career of education in B. Tech (EEE) at Sri Krishnadevaraya Engineering College in the year of 2013 and pursuing M. Tech (Electrical power systems) from Sri Krishnadevaraya Engineering College, gooty, Anantapur district (A.P). Her areas of interests include Electrical Power Systems

Dr. R. Ramachandra has completed his professional career of education in B. Tech (MECHANICAL) from JNTU Hyderabad. He obtained M. Tech degree from JNTU, Hyderabad. He obtained Ph. D degree from JNTU, Hyderabad At present working as Professor and Principal in *Sri krishna Devaraya Engineering College, Gooty of Anantapuramu* district (AP).

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