ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

(An ISO 3297: 2007 Certified Organization)

Vol. 4, Issue 5, May 2015

A Topology to Limit Fault Current in the Distribution System

P.Barathi[1], R.Pradeep[2]

PG Student, Dept. of EEE, SNS College of Technology, Coimbatore, Tamilnadu, India [1]

Assistant Professor, Dept. of EEE, SNS College of Technology, Coimbatore, Tamilnadu, India [2]

ABSTRACT: In this project new concept is proposed which is fault current limiting DVR. Fault is detected by sensing the load current and its rate of change. In order to protect the sensitive equipment fault current is limited such that life of the equipment and the quality of the supply is improved. Bidirectional thyristor switches are used on the output side of PCC to limit the fault current. Switches are activated under fault condition and de-activated under normal condition. This is modeled using MATLAB SIMULINK.

KEYWORDS: Dynamic voltage restorer (DVR), fault current limiter (FCL), voltage sag.

I INTRODUCTION

Power quality problems become a major issue at all the levels of power sector. The problems arises in terms of sag, swell, transients occur mainly due to the usage of sensitive and critical loads. Hence for a reliable power system, power quality problems are to be minimized. Power electronic controllers are designed such as active filters, passive filters. Lossless passive filters consist of LC tuned component. Passive filters are widely used due to its low initial cost and high efficiency. Though it is advantageous, the main drawbacks of this filters are suitable for fixed compensation, instability and resonance present in supply as well as on the load side. Hence to overcome these drawbacks active filters are used. Active filters consist of shunt, series and hybrid filters. Series is used for voltage compensation whereas shunt is used for current compensation and hybrid is the combination both series and shunt. Though it is used as a filtering component and it is not satisfied to end users. Hence the advanced filtering technology is needed which is termed as custom power device.

Usually single line to ground fault occurs in the power system which results in terms of voltage sag. This is mainly due to the usage of sensitive and critical loads. Since power quality problem plays a major issue in power system and to deliver the uninterruptible power supply to consumer, effective custom power device is needed. Hence for voltage sag compensation most efficient custom power device used is Dynamic Voltage Restorer (DVR).DVR (Dynamic Voltage Restorer) is a static var device that has been used in transmission and distribution side. It is a series compensating device, which protects sensitive electric load from power quality problems such as voltage sags, swells, unbalance and distortion through power electronic controllers that use voltage source converters (VSC).

The basic principle of the dynamic voltage restorer is to inject a voltage of required magnitude and frequency, so that it can restore the load side voltage to the desired amplitude and waveform even though when the source voltage is unbalanced or distorted. The source of the injected voltage is the commutation process for reactive power demand and an energy source for the real power demand. In normal conditions, the dynamic voltage restorer operates in stand-by mode. However, during disturbances, nominal system voltage will be compared to the voltage variation. This is to get the differential voltage that should be injected by the DVR in order to maintain supply voltage to the load within limits. The dynamic voltage restorer is also used to mitigate the damaging effects of voltage swells, voltage unbalance and other waveform distortions.

ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

(An ISO 3297: 2007 Certified Organization)

Vol. 4, Issue 5, May 2015

A short-circuit fault is a fault condition that creates temporary or permanent low impedance current paths between two or more circuit terminals operating at different potentials. Most common short-circuit faults are either ground faults or line-to-line faults. Short-circuit faults could be caused by various reasons, such as insulation failure, operator error, animals while crossing power lines, and even a broken tree branch accidentally occur due to wind. The source and line impedances in a power system are usually small enough to ensure high operating efficiency in normal conditions. The fault impedance is not a constant, predictable value, but overall it is small in most short-circuit faults.

Due to the increase in load demand and in need of additional loads power transmission is to be high. So equipments performance will vary and its life is reduced due to this large variation. This results in equipments failure due to the increase in fault current and due to increase in fault current this will impose high cost for electric utilities. So that it is desirable to introduce a reliable device to limit the fault and to achieve the custom satisfaction. so in distribution side utility able to spend the cost for introducing limiting device on the distribution instead of bar gaining. So that, it is easy to receive to consumers without any interruption or voltage fluctuation. Due to an FCL's ability to rapidly change the impedance within the system, it mitigates the large potential fault current threats. Also, it brings in additional benefits to the system, such as enabling parallel operation, reducing voltage dips and enhancing system stability.
In this project to limit the fault current a new technique used is fault current limiting DVR. This topology operates in two modes: compensation mode and fault current limiting mode. Compensation mode is to compensate voltage fluctuation and unbalance. Fault current limiting mode is to limit the fault current during short circuit condition. Fault current limitation is achieved by introducing bidirectional thyristor switches at the output of the inverter terminal. This paper is organized as the following. in section II topology and its principle is proposed. In section III control strategy is proposed. In section IV simulation results and experimental results are proposed.

II DYNAMIC VOLTAGE RESTORER

Among the power quality problems such as (sags, swells, harmonics…) voltage sags are the most severe disturbances which occur on transmission line. In order to overcome these problems the concept of custom power devices is introduced recently. One of those devices is the Dynamic Voltage Restorer (DVR), which is the most efficient and effective modern custom power device used in power distribution networks. DVR is a recently proposed series connected solid state device that injects voltage into the system in order to regulate the load side voltage. It is normally installed in a distribution system between the supply and the critical load feeder at the point of common coupling (PCC). Other than voltage sags and swells compensation, DVR can also added other features like: line voltage harmonics compensation, reduction of transients in voltage and fault current limitations.

The basic function of the DVR is to inject a dynamically controlled voltage generated by a forced commutated converter in series to the bus voltage by means of a booster transformer. The momentary amplitudes of the three injected phase voltages are controlled such as to eliminate any detrimental effects of a bus fault to the load voltage VL. This means that any differential voltages caused by transient disturbances in the ac feeder will be compensated by an equivalent voltage generated by the converter and injected on the medium voltage level through the booster transformer.

III FAULT CURRENT LIMITER

Many factors can cause a fault in a power system. The fault current level can be relatively large, which may damage equipment in the power system and even cause permanent failure. Power systems have to be designed to withstand mechanical and thermal stresses during a fault. Power system protection devices detect fault conditions and operate circuit breakers and other devices to limit the damage. Today, fault current levels in land-based distribution systems are of increasing concern because they are generally rising due to the increasing capacity of connected distributed generation. Increasing fault current levels will require expensive network investment in upgrading equipment such as circuit breakers and transformers. There is a growing need therefore for fault current limiting devices embedded into electrical networks to avoid a large scale and expensive upgrade of existing switchgear. FCLs are expected to reduce fault current levels without adding additional impedance during normal operation. The capital cost of purchasing and installing FCLs must be less than the cost of upgrading the existing equipment before they can be attractive for commercial applications.

ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

(An ISO 3297: 2007 Certified Organization)

Vol. 4, Issue 5, May 2015

IV TOPOLOGY OF FCL-DVR

The topology of FCL-DVR comprises of three single phase bridges which is shown in fig.1.. Each single phase comprises of a shunt transformer, back to back converter, series transformer and crow bar bidirectional thyristor. The back to back power converter consist of rectifier and inverter where as the rectifier and inverter are connected with the help of a dc link capacitor. The supply is given to rectifier from the grid and the inverter output is given to grid. The crowbar bidirectional thyristor switches is connected across the output terminals of the inverter side in order to limit the fault current.

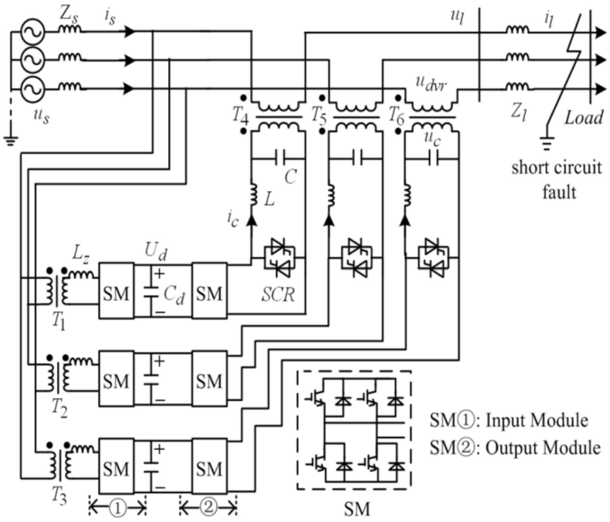

Fig.1. Topology of FCL-DVR.

The main objective is to limit the voltage during fluctuation or unbalance and to limit the fault current during load short. This is achieved by deactivating the faulty phase of the DVR the control over the system is done by activating thyristor switch and the reactors are inserted in grid to limit the fault current. This performance occur during load short. During voltage fluctuation DVR is in compensation mode to compensate the load voltage.

During short circuit fault or voltage sag fluctuation of the supply voltage will influence the stability of dc link voltage shunt transformer are delta connected since it will limit third harmonics and also fluctuation is less when compared to star connected. Hence high voltage side is delta connected.

V SIMULINK MODEL OF FCL-DVR

A OVER ALL SIMULATION

This system is modeled using MATLAB environment. The system of FCL-DVR consist of supply and load. This is connected with the help series and the shunt transformer. Shunt transformer gets the supply from the grid where as the series transformer is connected to the grid. So it takes the supply directly from the grid. Shunt transformer and series transformer are connected with the help of back to back connected thyristors and crow bar bidirectional thyristors. During normal operation if there is any change in voltage which results in terms of voltage fluctuation at that time DVR works in voltage compensation mode. This is done by deactivating the crowbar bidirectional thyristor switches during normal operating condition of DVR with the help of controller. During fault condition crowbar bidirectional thyristor switch starts conducting till the limitation of fault current

ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

(An ISO 3297: 2007 Certified Organization)

Vol. 4, Issue 5, May 2015

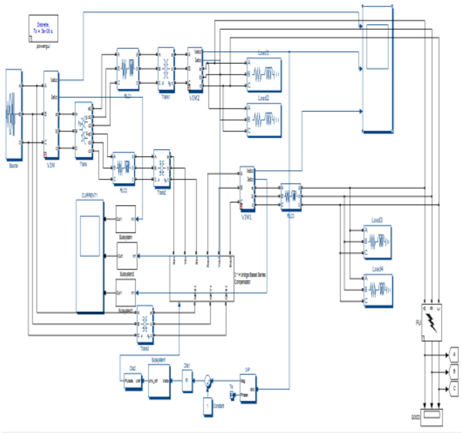

Fig.2. Simulation diagram of FCL-DVR.

B CONTROLLER OF FCL-DVR

Fig 3. Shows the controller of Fault Current Limiting DVR which consist of dc capacitor. This is connected between rectifier and the inverter module. Gate signals are selected to turn on and off at the right time by sensing the fault condition.

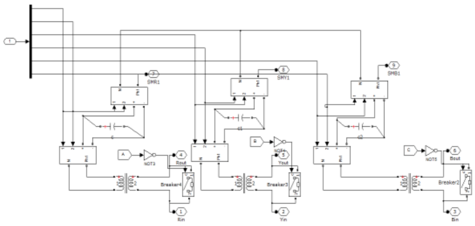

Fig.3.Controller diagram of FCL-DVR .

VI SIMULATION RESULTS OF FCL-DVR

Simulation has been shown for single line to ground fault, line to line fault, double line to ground fault and three phase fault for voltages.

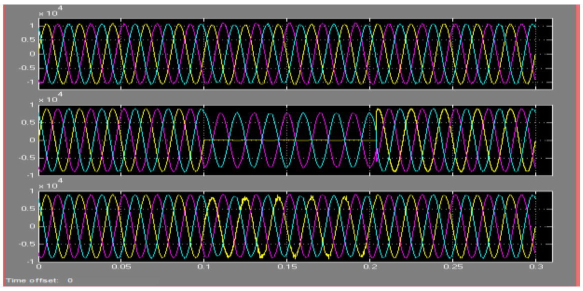

Fig 5 Single line to ground fault.

line to line fault is shown in fig 6

ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

(An ISO 3297: 2007 Certified Organization)

Vol. 4, Issue 5, May 2015

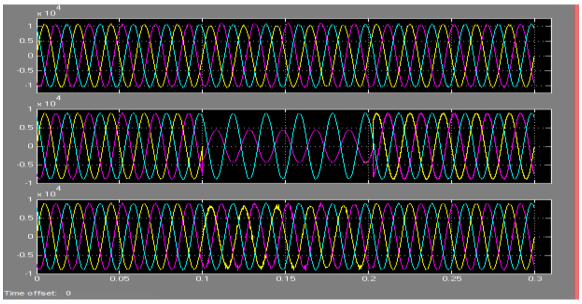

Fig 6 Line to line fault

Double line to ground fault in fig 7

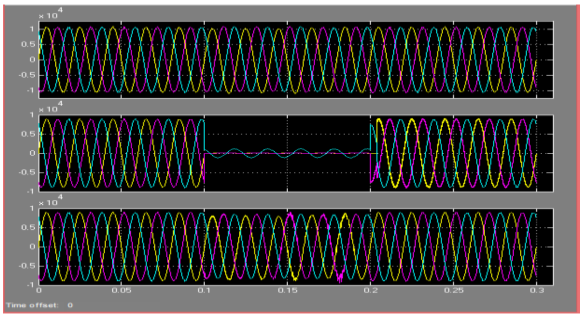

Fig 7 Double line to ground fault

Three phase fault is shown in fig 8

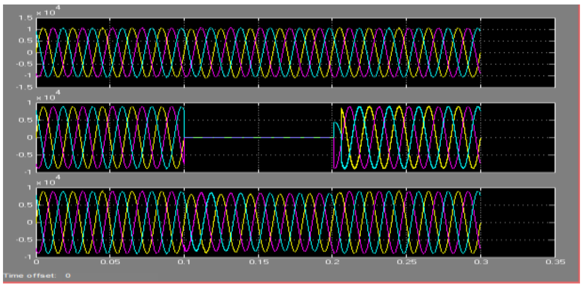

Fig 8 Three phase fault

The following graph shows for the current waveform of single line to ground fault, line to line fault, double line to ground fault and three phase fault.

Single line to ground fault in fig 9

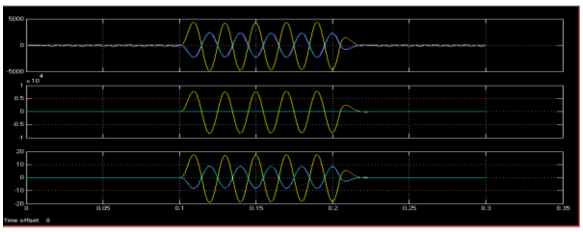

Fig 9 Single line to ground fault current

line to line fault in fig 10

ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

(An ISO 3297: 2007 Certified Organization)

Vol. 4, Issue 5, May 2015

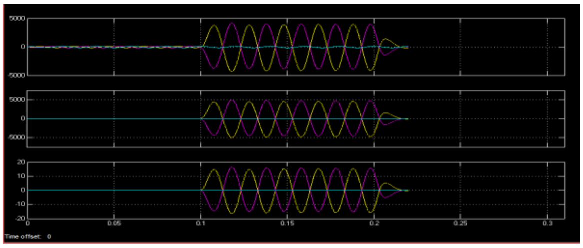

Fig 10 line to line fault current

Double line to ground fault in fig 11

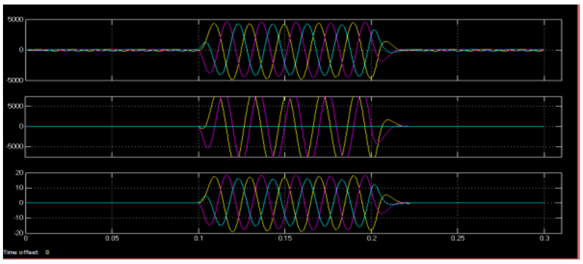

Fig 11 Double line to ground fault current

Three phase fault in fig 12

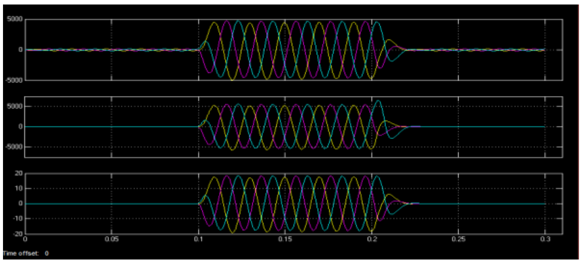

Fig 12 Three phase fault current

REFERENCES

[1] A. R. Fereidouni, B. Vahidi, and T. H. Mehr, "The impact of solid state fault current limiter on power network with wind-turbine power generation," *IEEE Trans. Smart Grid*, vol. 4, no. 2, pp. 1188–1196,Jun. 2013.

[2] T. Ghanbari, I. Shiraz, and E. Farjah, "Development of an efficient solid-state fault current limiter for microgrid," *IEEE Trans. Power Del.*,vol. 27, no. 4, pp. 1829–1834, Oct. 2012.

[3] R. F. Arritt and R. C. Dugan, "Distribution system analysis and the future smart grid," *IEEE Trans. Ind. Appl.*, vol. 47, no. 6, pp. 2343–2350, Nov. 2011

[4] M. H. Ali and B. Wu, "Comparison of stabilization methods for fixed speed wind generator systems," *IEEE Trans. Power Del.*, vol. 25, no. 1,pp. 323–331, Jan. 2010.

[5] F. M. Mahdianpoor, R. A. Hooshmand, and M. Ataei, "Dynamic voltage restorer based on flying capacitor multilevel converters operated by repetitive control," *IEEE Trans. Power Del.*, vol. 26, no. 2, pp. 882–890, Jun. 2011.

[6] R. K. Behera, S. K. Parida, and W. Gao, "Performance improvementof a wind power distribution station using a dynamic voltage restorer,"in *Proc. North Amer. Power Symp. (NAPS)*, Arlington, TX, USA, 2010, pp. 1–6.

[7] S. S. Choi, T. X. Wang, and D. M. Vilathgamuwa, "A series compensator with fault current limiting function," *IEEE Trans. Power Del.*, vol. 20, no. 3, pp. 2248–2256, Jul. 2005.

[8] F. Badrkhani Ajaei, S. Farhangi, and R. Iravani, "Fault current interruption by the dynamic voltage restorer," *IEEE Trans. Power Del.*, vol. 28, no. 2, pp. 903–910, Jun. 2013.

[9] M. M. R. Ahmed, "Comparison of the performance of two solid state fault current limiters in the distribution network," in *Proc. Power Electron. Mach. Drives (PEMD)*, York, U.K., 2008, pp. 772–776.

[10] C. N.-M. Ho, H. S. H. Chung, and K. T. K. Au, "Design and implementation of a fast dynamic control scheme for capacitor-supported dynamic voltage restorers," *IEEE Trans. Power Electron.*, vol. 23, no. 1, pp. 237–251, Jan. 2008.