A BESS BASED DVR FOR NEUTRAL CURRENT ELIMINATION IN DISTRIBUTION SYSTEM

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ABSTRACT

Here in this paper investigates the injection scheme for Dynamic Voltage Restorer (DVR) for Neutral wire Current Compensation in three phase Four wire Distribution System. Here DVR focus on the Special method of control for Voltage source converter for effective reactive power control of Battery Energy Storage System. The Required load voltage is compared using the unit vectors calculation Method. The synchronous reference frame theory is used for the conversion of load voltages from rotating vectors to the stationary frame. The Mitigation of the Neutral Current Technique is demonstrated using a reduced-rating DVR with Effective control of battery energy storage section (Battery Enable Storage Section). Construction, Developing, analyzed and verified using MATLAB/ Simulink to validating the theoretical evaluation findings.

Keywords: Dynamic Voltage Restorer (DVR), Power Quality, Neutral Current Compensation, Distribution System.

I. INTRODUCTION

Majorly Distribution system had Power Quality Problems (PQ) such as Voltage Sag, Swell, high Reactive Power, harmonics, excessive Neutral current, etc. To overcome the Power Quality problems many standards are implemented. Due to Rapid increment of Critical and Sensitive load in the Distribution System. Distribution system had rapid increment of nonlinear loads by years due to usage of power electronic devices in industry as well as by domestic consumers of electric source. Because of these unbalanced loads has reactive power fluctuations, harmonics, Voltage imbalance and Neutral Current tend to increase in the distribution system. Custom Power Devices are mainly providing the Protection under the different power quality Problems. Custom Power Devices are divided into three categories those are Series Connected devices as Dynamic Voltage Restorer (DVR), Shunt Connected devices as Distributed Static Compensator (D-STATCOM) and Combined Series –Shunt Connected Devices as Unified Power Quality Conditioner (UPQC). Dynamic Voltage Restorer is most effective Device for Voltage sag situation, swell situation and harmonics in Supply and Neutral Current balancing complications. Then it can safeguard the Sensitive and Unbalanced loads from all power quality problems.

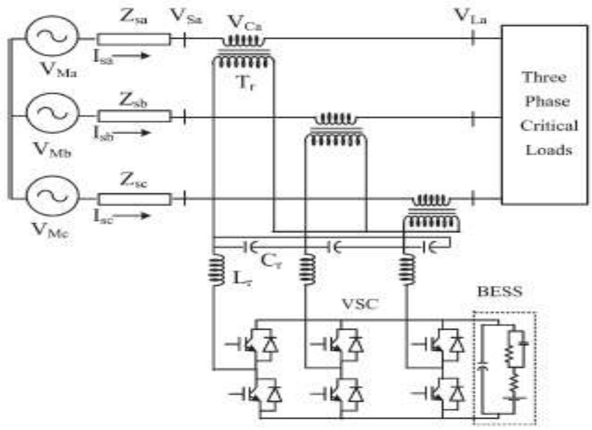

Fig.1 Schematic of the DVR-Connected System

Voltage sags in an electrical grid are not every case possible to mitigate because of the finite clearing time of the faults that reason the voltage sags and the propagation of sags from the transmission and distribution systems to the reduced voltage loads. Voltage sags are the common causes for interruption in generating stations and for end user dives malfunctions in general. In particular tripping of electrical device in a production transmission line can cause production interruption in generating stations and significant loss of generation. One clarification to this difficult is to make the device itself more accepting to sags either by intelligent maintenance or by storing ride through energy in the device. A marginal solution instead of changing each component in a plants to be tolerant beside voltage sag is to integrate a plant wide uninterruptable power supply system for longer power fluctuations or a DVR on the incoming supply to eliminate voltage sags for little period. Dynamic Voltage Restorer can capable to eliminate most of the sags and reduces the risk of load tripping for very deep sags, and reduces the complexity of load tripping for very extensive time sags, but their main disadvantages are their backup losses, the apparatus cost and also the security scheme essential for downstream short circuits.

II. OPERATION OF DVR

The schematic diagram of DVR with Battery Energy Storage system is shown in the above Fig.1. The Essential Voltage addition is done by the Shunt Capacitor in the BESS system and that Effective Control is done by the use of Voltage source Converter in the DVR so effective Reactive Power Compensation is Possible by the use Power Electronic Converter placement in the Distribution System and the Active power is Constant throughout the System means the Unity of Power is maintained in the Distribution System without having any Power Quality Issues. If any voltage Imbalance occur in the Distribution system Dynamic voltage Restorer has to send the Required Reactive power, if any un-necessary reactive power is placed in the Distribution system Dynamic Voltage Restorer (DVR) has to absorb the Reactive Power in the Distribution System, so lastly Reactive Power balance is done by the Dynamic Voltage Restorer depends on the Load Requirement.

The voltage added by the DVR in phase A V_{Ca} is such that the load voltage V_{La} is of rated magnitude and undistorted. A three-phase DVR is coupled to the line to inject a voltage in series using Multi-Winding Transformer *Tr*. *Lr* and *Cr* characterizes the filter apparatuses used to eliminate the ripples in the added voltage by the DVR into the Distribution system. A three-leg VSC with insulated-gate bipolar transistors (IGBTs) is used as a DVR, and a BESS is connected to its dc bus.

III. CONTROL OF DVR

The compensation for Neutral Current in Three Phase Four Wire by using a DVR can be performed by injecting or absorbing the reactive power or the real power. When the extra voltage by DVR is in quadrature with the current at the fundamental frequency, the compensation is made by injecting reactive power and the DVR is with a BESS system. However, if the DVR voltage is in-phase with the flowing current, DVR inserts real power, and hence, a battery is required at the dc bus of the Voltage Source Converter. The control method implemented should consider the limitations such as the voltage injection capability (converter and transformer rating) and optimization of the size of energy storage

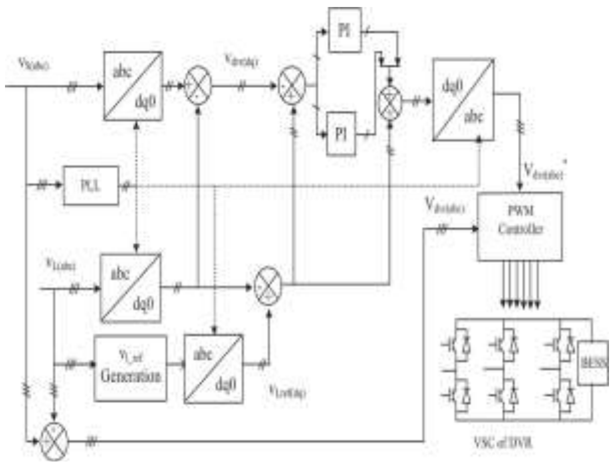

Fig. 2. Control Diagram of DVR

3.1 Control of DVR with BESS for Voltage Sag, Swell, and Harmonics Compensation

Fig. 2 shows a control unit of the DVR in which the SRF theory is used. The voltages at the Point of Common Coupling (PCC) V_S and at the load Voltage V_L are sensed for derive the IGBTs' gate signals. The Required load voltage V_L^* is extract using the derived unit vector. By Applying the Park Transformation to Load voltages (V_{La}, V_{Lb}, V_{Lc}) are converted to the rotating reference frame using $abc-dqo$ translation with, unit vectors $(sin\theta, cos\theta)$ obtained using a phase-locked loop .

By the Phase Locked Loop and we can obtain the dq coordinate values for better simplification of Three phase Network. The error between the desired and actual DVR voltages in the rotating reference frame is controlled utilizing two proportional integral (PI) controllers. The desired DVR voltages $(v^{*}_{dvra}, v^{*}_{dvrb}, v^{*}_{dvrc})$ and nominal Dvr voltages $(v_{dvra}, v_{dvrb}, v_{dvrc})$ are utilized in a pulse width modulation (PWM) controller too produce triggering pulses to a VSC of the DVR. The PWM controller is working with a switching frequency of 10 kHz.

3.2 Control of Self-Supported DVR for Voltage Sag, Swell, and Harmonics Compensation

Here in this project a capacitor sustained DVR integrated to three phase sensitive loads and also consist of control block of the DVR in which the SRF theory is utilized for the control of self-sustained DVR is suggested. The voltages at the PCC are modified to the rotating reference frame utilizing abc-dq0 conversion utilizing Park's transformation regulator strategy. The misrepresentations and the oscillatory components of the voltage are mitigated by the make use of low pass filters. The components of voltages in the d axis and q axis are represented as follows.

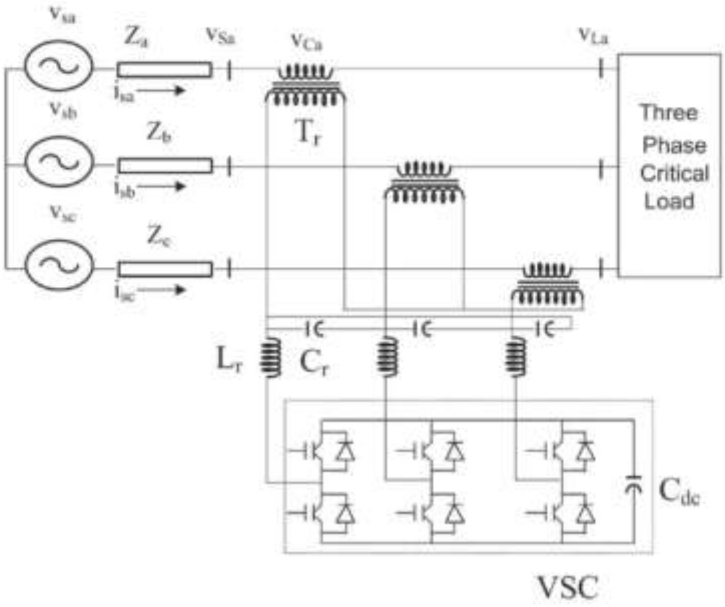

Fig 3 Schematic of the Self-Supported DVR

$$v_d = v_{ddc} + v_{dac}$$

$$v_q = v_{qdc} + v_{qac}.$$

The compensating control technique for compensation of voltage quality problems considers that the load terminal voltage should be of rated magnitude and not distorted. In order to control the dc bus voltage of the self-sustained capacitor a PI controller's is utilized at the dc bus voltage of the DVR and the output is considered as a voltage V_{cap} for meeting its losses.

$$v_{cap}(n) = v_{cap}(n-1) + K_{p1}\_ v_{de}(n) - v_{de}(n-1)\_ + K_{i1} v_{de}(n)$$

The desired d axis load voltage is represented as follows.

$$V * d = v_{ddc} - v_{cap}.$$

The load terminal voltage amplitude VL is maintained to its reference voltage $V * L$ utilizing another Proportional Integral controller. The output response of the Proportional Integral controller is considered as the reactive component of voltage for voltage controlling of the load terminal voltage. The desired(v_{La}^*, v_{Lb}^*, v_{Lc}^*) load voltages in the abc frame are achieved from a reverse Park's conversion. The error between intended load voltages (v_{La}, v_{La}, v_{La},) and desired load voltages is used over a controller to produce gating pulses to the VSC of the DVR.

IV. MODELING AND SIMULATION

The DVR integrated system consisting of a three phase supply three phase sensitive loads, and the series injection transformer is developed. The main Simulink model is designed in MATLAB/Simuink environment along with a simpower system toolbox and is also presented in this paper. An equivalent load considered is a 10 kVA 0.8 power factor lag linear load.

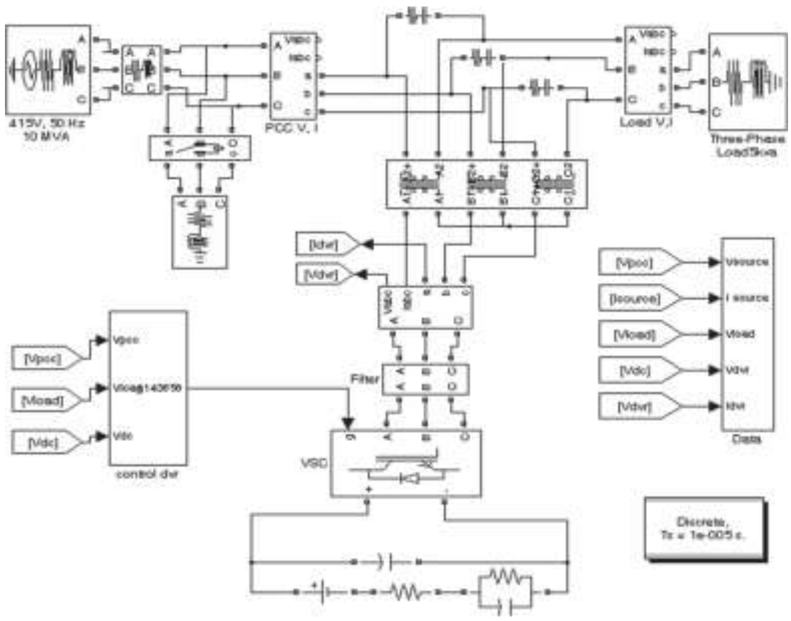

Fig. 3 MATLAB-Based Model of the BESS-Supported DVR-Connected System

V. PERFORMANCE OF THE DVR SYSTEM

The operating performance of the DVR is investigated for various supply voltage fluctuations such as voltage sag condition and voltage incremental condition. The transient operating presentation of the system under voltage sag and voltage swell conditions. At certain time a voltage sag in supply voltage is created for five cycles and also swell in the supply voltage is generated for limited cycles. It is clear that the load voltage is meticulous to constant magnitude under both sag and swell conditions. The PCC voltages, load voltages, DVR voltages and the amplitude of load voltage and PCC voltage, source current and the desired voltage of load and dc bus voltages are also illustrated in this paper. Here in this paper the load and PCC voltages of phase A also illustrated which indicates the in phase injection of voltage by the DVR. The compensation of harmonics is the supply voltages also investigated in this paper.

The load voltage is regulated sinusoidal by delivering proper compensation voltage by the DVR. The total harmonics distortion of the voltage at the PCC, the current at the supply side and voltage at the load side depicted respectively. It is clear that the load voltage THD is mitigated to a level of 0.66% from the Common Coupling Point (PCC) voltage of 6.34%.

The magnitudes of the voltage delivered by the DVR for eliminating the similar kinds of sag in the supply with various angles of injection are investigated. The injected voltage series current, and kilovolt ampere ratings of the DVR for four injection techniques are also explained in this paper. In the first method in phase injected voltage is represented in pharos notation. In second method a DVR voltage is injected at an angle of 45 degree. The injection of voltage in quadrature with the line current.

The required rating of compensation of the voltage sags and swells utilizing those techniques. The operating performance of the self-sustained DVR for compensation of voltage sag and voltage swell is also investigated. It is observed that the injected voltage is in quadrature with the supply current, and hence a capacitor can sustenance the dc bus of the Dynamic Voltage Restorer. Even though the added voltage is sophisticated compared with an in phase injected voltage.

VI. CONCLUSION

The working procedure of a DVR has been validated with a new control strategy utilizing different kinds of voltage injection schemes. A comparison of the operating performance of the DVR with various schemes has been performed with a condensed rating VSC, including a capacitor sustained DVR. The reference load voltage has been estimated utilizing the control technique of unit vectors and the control of DVR has been obtained as er the required levels, which reduces the error of voltage addition. The SRF theory has been used for approximating the desired DVR voltage levels. It is concluded that the voltage injection in phase with the PCC voltage results in reduced rating of DVR but at the cost of an energy source at dc bus.

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