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Research article

VOLTAGE SAG MITIGATION IN LV AND HV PLATFORM USING SMES BASED DVR

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ABSTRACT

DVR can be effectively provides a fine solution to power quality related concerns. As per the PQ issues sag is the mostly happen problem. By the Superconducting magnetic energy storage (SMES) technology based DVR the sag is mitigated and real power is restored and thus wastage is overcome, providing protection to consumers from grid voltage fluctuations. This paper analyses the operation principle of the SMES linked DVR technology and its design based on simple PI and voltage feed forward control. Using MATLAB /SIMULINK, the model of the SMES based DVR was plotted and the dynamic response of the DVR on voltage sag is evaluated in transmission system of nonlinear loads by inserting a fault and for a low voltage platform with an asynchronous drive using MATLAB/SIMULINK simulation and the simulation tests are performed to evaluate the system performance.

Keywords: DVR, technology, power system, voltage

INTRODUCTION

Now day's power systems have been experiencing drastic changes and disturbances in electric power generation, transmission, distribution, and end-user facilities. Continuous electric load growth and higher power transfer in a wide interconnected network leads to complicated, security lack power system operation. In addition, certain factors such as technical, economical, environmental and governmental regulation constrains put limitation on power system planning and operation. Power system engineers day by day facing so many risks and challenges over the PQ concern solutions and are

seeking solutions to overcome and operate the system in more flexible and controllable manner. So role of energy storage devices play vital roles. As Energy storage appears to be beneficial to utilities since it can decouple the instantaneous balancing between the demand and the supply. Therefore it allows the increased asset utilization, facilitates the penetration of renewable sources and improves the flexibility, reliability and efficiency of the grid. Here we are more concern with short term response energy devices like Flywheel and super capacitor and are having less power rating and energy rating so they cannot use for higher power application. So in order to overcome this deficiency SMES has been used to improve performance of power system as it is having high power rating with max efficiency than any other energy storage devices. Recent development and advances on both superconducting and power electronics technology have made the application of SMES (superconducting magnetic energy storage) systems a viable choice to bring solutions to some of the problems experienced in power systems.. In This paper, proposes a superconducting magnetic energy storage unit as the energy storage unit of the DVR. In section II, the configuration of SMES is analyzed. In section III, the dynamic response of the SMES based DVR on voltage sag is evaluated in transmission system of nonlinear loads by inserting a fault and for a low voltage platform with an asynchronous drive using MATLAB simulation

CONFIGURATION OF DVR

A DVR is a sophisticated custom power device that serially injects a dynamically controlled voltage Vinj(t) to the bus voltage by means of a injection transformer as depicted in Figure1. The amplitudes of the injected phase voltages are controlled so as to eradicate any of the detrimental effects of bus fault to the load voltage VL(t). This means that if any detrimental fault occurs then the differential voltage get arise in the AC feeder will be compensated by an equivalent voltage generated by the converter circuit and is injected on the medium voltage level through the injection transformer. The DVR works independently, provides that the whole system remains connected to the supply grid. The, reasonable fact behind it is due to the components infinite impedence because of that the zero sequence part of a disturbance will not pass through the step down transformer. For most of the time the DVR is in a "nothing to do" status except bus voltage monitoring. This means it does not inject any bus voltage (Vinj(t)= 0)independent of the load current. When ever any sag occurs a v_{DVR} is supplied as the difference of v_{presag} and v_{sag} by DVR in the form of active power with help of DC energy storage and required reactive power is generated internally without any means dc storage. An equivalent circuit diagram of the DVR and the principle of series injection for sag compensation is depicted in Figure 1.

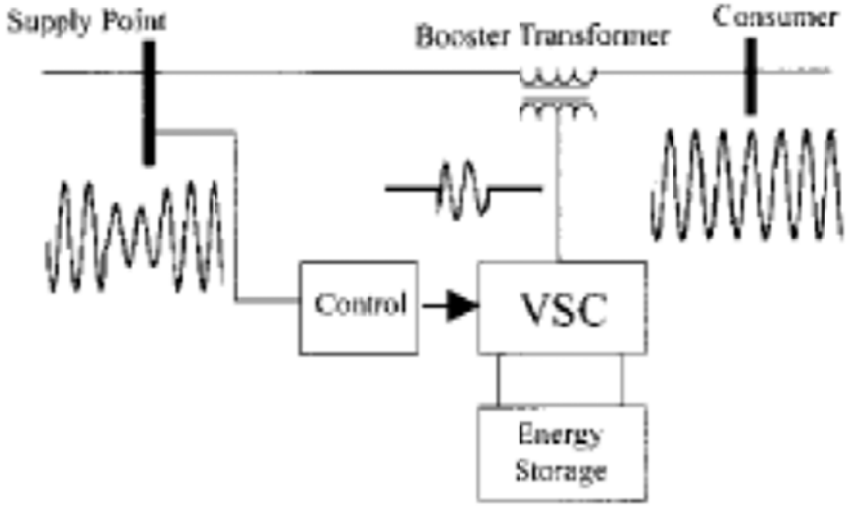

Figure 1: DVR configuration in line

SMES UNIT

In SMES unit a super conducting coil is used which generates a magnetic field by the flow of DC current,where the energy is stored,and is long lasting compare to other short term energy storage units. SMES consists of super conducting

magnetic energy storage unit, capacitor bank, voltage source inverter (VSI), low pass filter and a voltage injection transformer.

SMES system consists of main system and its sub-systems. Where the superconducting coil is the prime important section of a SMES system, which is placed in a cryostat or dewar consisting of a vacuum vessel and a liquid vessel .The liquid vessel which keeps the system temperature by providing proper cooling set up's cryogenic system is also keeps the temperature below the critical temperature. An ac/dc PCS is used mainly for two purposes:

1.To convert electrical energy from dc to ac.

2.To provide proper charging and discharging of the coil.

Finally, a transformer which provides the power system connection and coordination and thereby the PCS operating voltage will reduce to an acceptable levels .

Although SMES system having fine efficiency,reduced positive cost by less fuel consumption, and fast response capability.

INTEGRATION OF SMES WITH DVR

The basic structure of a DVR based on SMES is shown in Fig.2

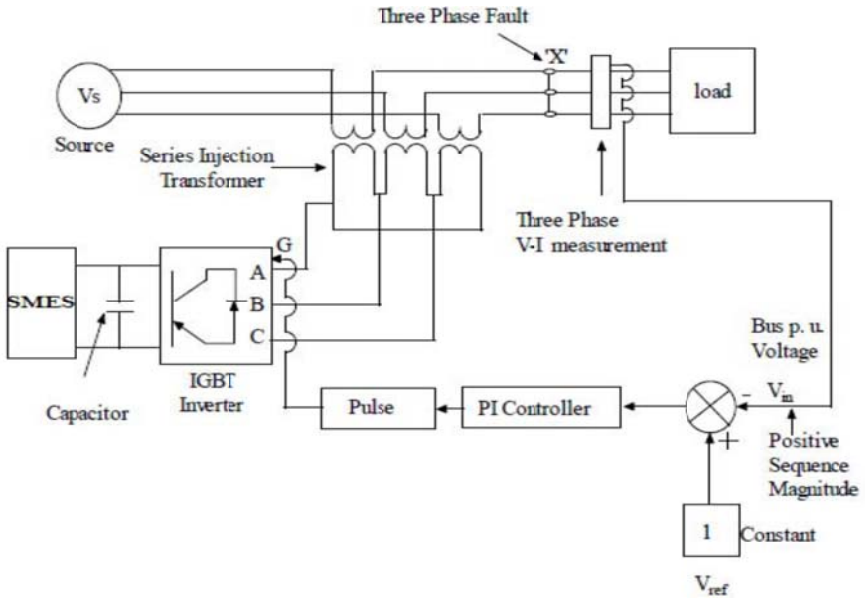

Figure 2 : SMES based DVR configuration

CONTROLLER SECTION

Voltage sag is created at load terminals by a three phase fault as shown in Fig.4. Load voltage is converted into per unit quantity and is passed through a sequence analyzer. The magnitude is then compared with reference voltage (*Vref*) through which error signal is fed to PI controller.

This voltage is then fed to triggering circuit. Pulse width modulated (PWM) control technique is applied for inverter switching so as to produce a three phase 50 Hz sinusoidal voltage at the load terminals. Chopping frequency is in the range of a few KHz. The PI controller processes the error signal and generates the required angle δ to drive the error to zero.

An advantage of a proportional plus integral controller is that integral term causes the steady-state error to be zero for a step input. PI controller input is an actuating signal which is the difference between the *Vref* and *Vin.*

The output of error detector is

Vref - Vin. (f)

Vref equal to 1 p.u. voltage
Vin voltage in p.u. at the load terminals.
The controller output when compared at PWM signal generator results in the desired firing sequence.

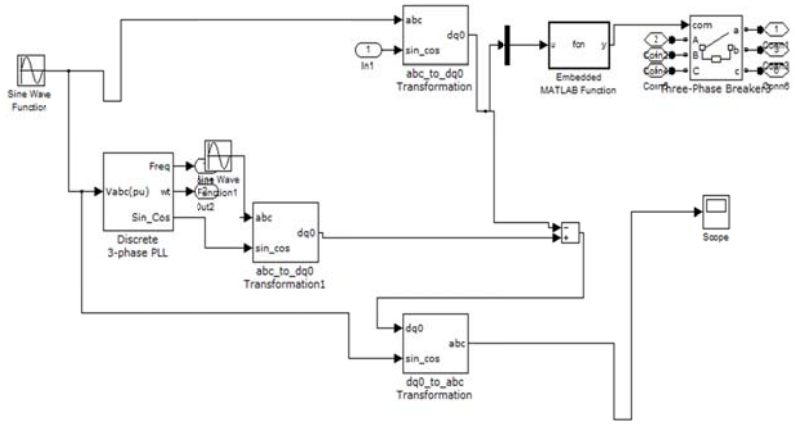

Figure 3 : voltage feed forward controller

Fig. 3 shows the Simulink model of DVR control. Transformation of supply voltage from abc frame to dqo frame and input to the function block is to detect voltage sag. If Vd is in between 0.985pu to 1pu,makes the function output closes the circuit breaker,and is connected in parallel with DVR, there by DVR get bypassed. If Vd value lesser than 0.985pu,then suddenly function output opens the three-phase breaker. DVR is connected serially through a booster transformer to the power system and injects voltage to mitigate sag or fluctuation as per the injected voltage reference. This reference signal is derived by comparing supply voltage with reference voltage in dq0 frame. Along with the phase information of the supply voltage from phase-locked loop, will converts the difference to abc frame.PLL also helps in the synchronization of signal also.

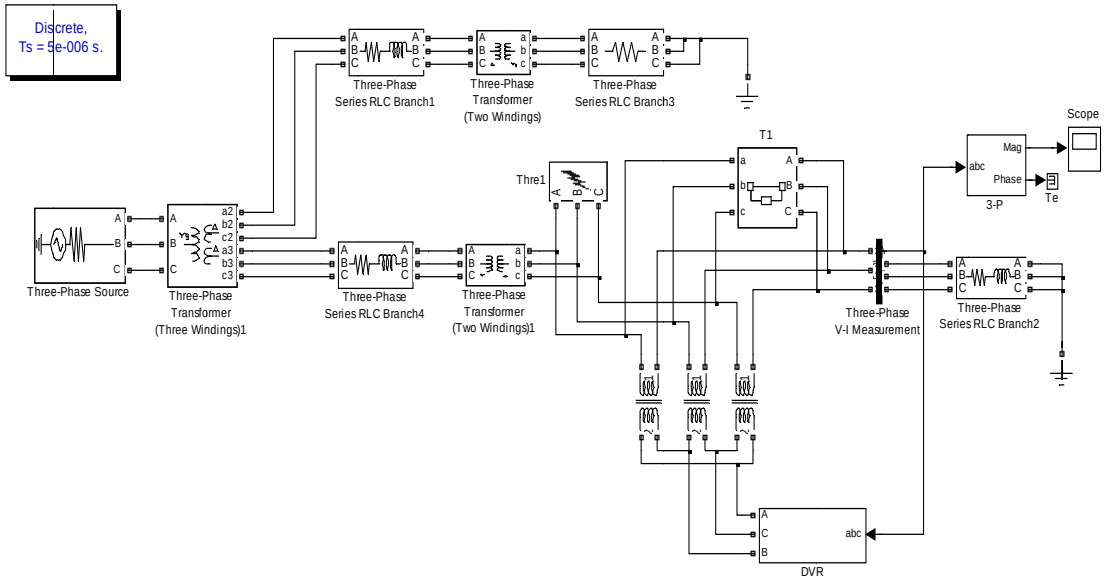

Figure 4: 3 Matlab circuit of SMES based DVR

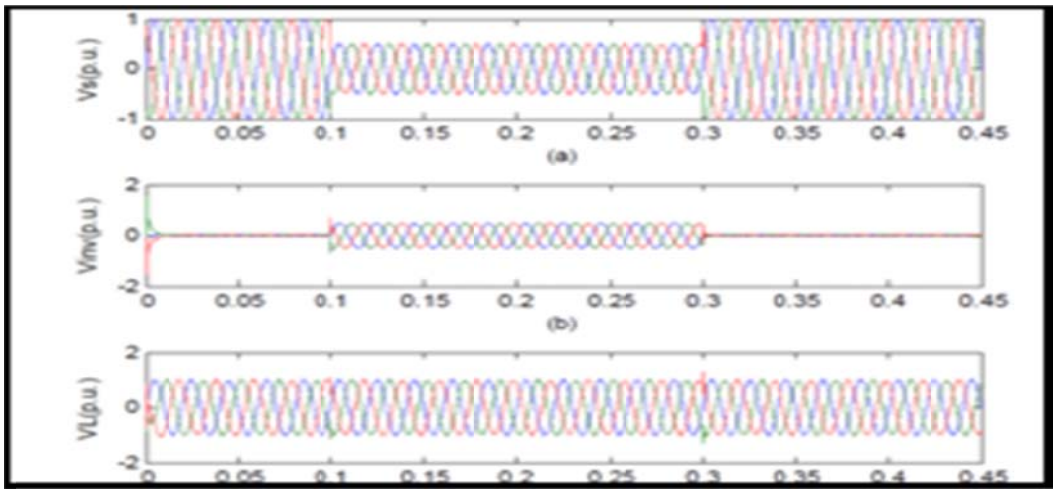

Figure 5: 3 phase fault mitigation with SMES based DVR

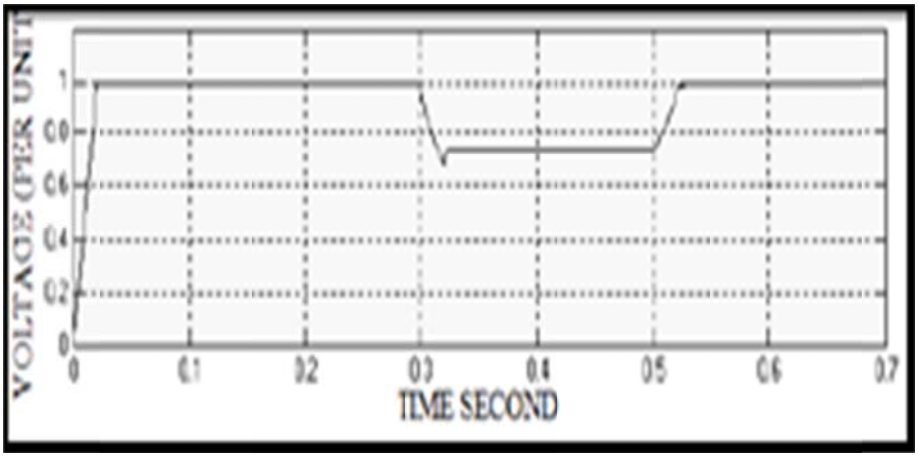

Figure 6: 3 phase PU voltage without SMES based

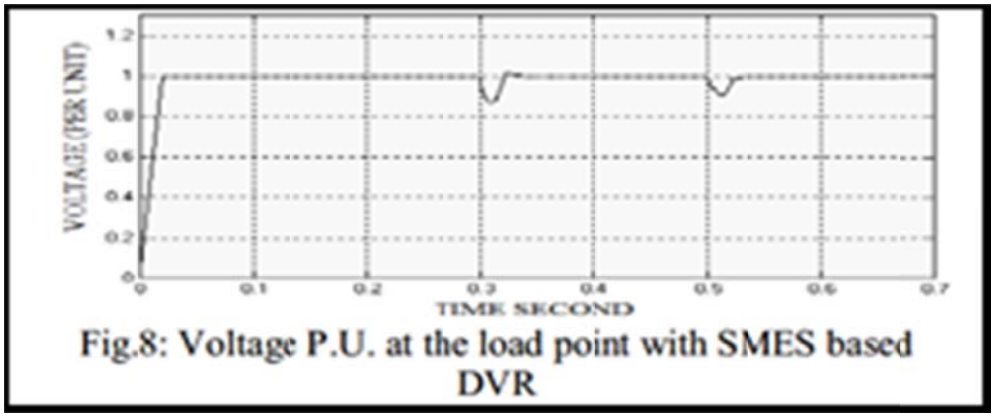

Figure 7 : PU voltage at 3 Φ Fault at load with DVR

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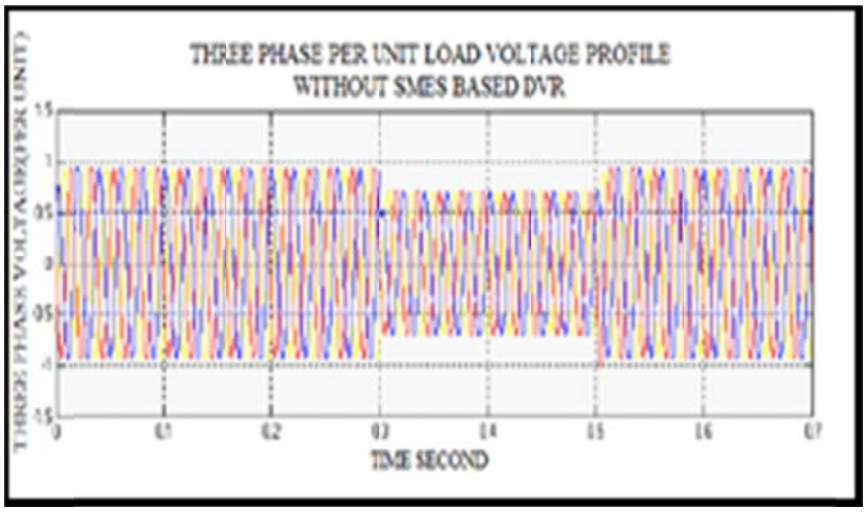

Figure 8: simulation output of IM load without DVR

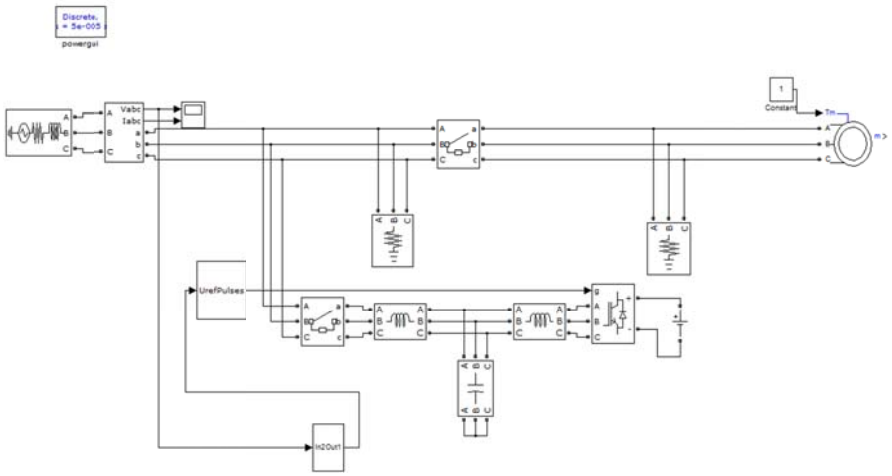

Figure 9: Matlab circuit in IM load using DVR

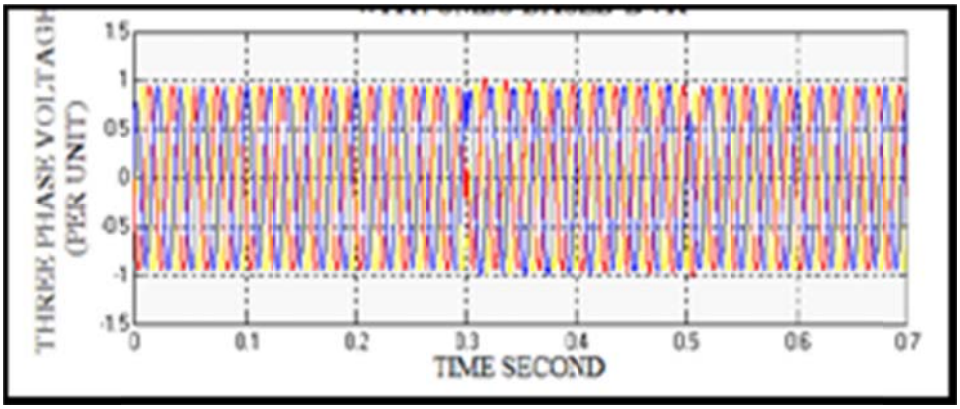

Figure 10 : Simulation output of sag compensation in IM load by DVR

When suddenly an voltage drop occurs, automatically speed dips occur and there by torque reduces,it affects motor characteristics.so if we use a DVR ,the voltage sag can be compensated ,there by speed-torque compensation can be improved.

CONCLUSION

This paper has presented a DVR system with SMES based on the V-source inverter for a high voltage transmission system and a low voltage platform with induction motor load.In transmission system the fault is inserted and how it compensates while a DVR is connecting serially is explained with corresponding outputs.In low voltage platform,,the unbalances occurs as sag when an induction motor suddenly starts are studied and mitigated ,there by its torque speed characteristics can be improved. The operating principle, analysis and the Sag compensations of DVR are presented. Overall we can concludes, the V-source inverter DVR system has several unique advantages that are very desirable for many DVR applications ,since it can produce any desired output ac voltage, even greater than the line voltage and can provide ride through without any additional circuits and energy storage while sag occurs. Also can able to reduces in-rush and harmonic current. The voltage source technology is applied to the entire spectrum of power conversion .The Simulation results prove that the SMES can be a useful alternative DC source for the DVR.

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