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Voltage Sag Enhancement of Grid Connection Hybrid PV-Wind Power System

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Abstract— **The series connected DVR will inject three-phase compensating voltages through the three-phase injection transformer or three single-phase injection transformers with the main supply. The filtered VSI output voltage is boosted to the desired level with the injection transformer. The transformer also isolates the DVR circuit from the distribution system. The capacity of the voltage source inverter (VSI) and the values for the link filter connected between the injection transformer and the inverter play a crucial in the design of the DVR. In this research project, new Dynamic Voltage Restorer (DVR) topology has been proposed. The capacity of the voltage source inverter (VSI) and values of the link filter is small that will improve the compensation capabilities for voltage harmonic, swell and voltage sag mitigation under various fault conditions. The new RLC filter is able to eliminate the switching harmonics. The capacity of the dc supply voltage is reduced when the value of inductance is small. The new DVR topology has high efficiency and the ability to improve the quality of voltage. Outline architecture of the RLC filter parameters for the specific model has been presented. The new DVR with proposed controlled Dynamic Voltage Restorer topology is modeled and simulated using the MATLAB. The control scheme has good control dynamics with minimum transient current overshoot. The simulation results under transient performance are good**

Keywords—component,Superconducting magnetic energy storage (SMES); Dynamic Voltage Restorer(DVR); Voltage Sag, swell and interruption; Pulse-width modulated (PWM)*(key words)*

I. Introduction

Day to day there is an increase in the intensity of sensitive loads in power systems, so the power quality issues play a vital role in the present days. There is extreme power quality problems mentioned as voltage swell, voltage sag, harmonics, flicker etc. Voltage sag generally origin from the faults on load or supply side, maloperation, electrical motor startup, electrical heaters turning on, etc. So the DVR is mitigating the voltage sag through injecting the voltage. Power quality problems are affected due to the appearance of various nonlinear loads such as diode bridge rectifiers, adjustable speed drives (ASD), switched mode power supplies (SMPS), and laser printers etc. As stated on voltage sag is the reduction in RMS voltage from 0.1pu to 0.9pu for a short time period of 0.5 cycles to few cycles. Generally, faults occurred in distribution systems having a reduction from 40% to 50% of the rated voltage until less than 2secs. Due to the above mentioned power quality problems on sensitive loads, minimization their effects are necessary. Furthermore, new power electronic devices are introduced and named as custom power devices. These devices are distribution static compensator (D-STATCOM), unified power quality conditioner (UPQC), dynamic voltage restorer (DVR). DVR is the perfect solution for restoring the load voltage at output terminals. When, the quality of source voltage is disturbed. DVR compensate the voltage sag with an appropriate injection of voltage in series with grid voltage, in order to maintain the rated load voltage with balance mode condition. Generally, DVR consists of inverter, injection transformer and energy storage device. The design of new inverter topology is to inject the voltage with proper control of the magnitude and phase angle, to maintain the constant load voltage and avoid disturbances at load voltage. The basic system model of DVR DVR is a power electronic switching device which is connected in series to the load voltage bus to inject a dynamically controlled voltage. This voltage can eliminate effects of fault of voltage bus on a sensitive load. DVR is equipment used to recover a voltage or improve the voltage quality on the load side and its position is mounted in series between the source and the load. DVRs are coupled in series with distribution systems to protect sensitive equipment against the occurrence of voltage drop. The basic function of the DVR is to detect the occurrence of voltage drops that occur on the power system channel, and then inject the voltage to compensate for the voltage drop that occurs. Therefore the DVR is placed close to the sensitive load that is protected. The DVR works depending on the type of interference or an event occurring in the system, generating the injected voltage.obtained from the DC energy storage unit and then converted to AC voltage by the voltage source inverter (VSI. To set the controller on the DVR is used dq0 transformation or Park transformation. The dq0 method will provide information on the depth of the voltage drop and the phase shift with the starting point and end point of the voltage drop

II. LITERATURE SURVEY

Johan H. R. Enslin and Peter J. M. Heskes,[1] "Harmonic interaction between a large number of distributed power inverters and the distribution network," In this paper discussed the harmonic interaction between a large number of distributed power inverters and the distribution network. This paper is to analyze the observed phenomena of harmonic interference of large populations of these inverters and to compare the network interaction of different inverter topologies and control options.

UffeBorup, FredeBlaabjerg and Prasad N. Enjeti ,[2] "Sharing of nonlinear load in parallel-connected three-phase converters," Presented about the sharing of linear and nonlinear loads in three-phase power converters connected in parallel, without communication between the converters. The paper focuses on solving the problem that arises when two converters with harmonic compensation are connected in parallel.

Pichai Jintakosonwit Hideaki Fujita, Hirofumi Akagi and Satoshi Ogasawara, [3] "Implementation and performance of cooperative control of series active filters for harmonic damping throughout a power distribution system," This paper proposes cooperative control of multipleactive filters based on voltage detection for harmonic damping throughout a power distribution system. The arrangement of a real distribution system would be changed according to system operation, and/or fault conditions. In addition, series capacitors and loads are individually connected to, or disconnected from, the distribution system.

Pedro Rodríguez, JosepPou, Joan Bergas,J. Ignacio Candela , Rolando P. Burgos and DushanBoroyevich ,[4] "Decoupled double synchronous reference frame PLL for power converters control," Presented the detection of the fundamental-frequency positivesequence component of the utility voltage under unbalanced and distorted conditions. Specifically, it proposes a positivesequence detector based on a new decoupled double synchronous reference frame phase-locked loop (PLL), which completely eliminates the detection errors of conventional synchronous reference frame PLL's. This is achieved by transforming both positive- and negative-sequence components of the utility voltage into the double SRF, from which a decoupling network is developed in order to cleanly extract and separate the positive- and negative-sequence components.

SoerenBaekhoejKjaer, John K. PedersenandFredeBlaabjerg,[5] "A review of single-phase grid-connected inverters for photovoltaic modules" presents a Review of Single-Phase Grid-Connected Inverters for Photovoltaic Modules. This paper focuses on inverter technologies forconnecting photovoltaic (PV) modules to a single-phase grid. The inverters are categorized into four classifications: 1) the number of power processing stages in cascade; 2) the type of power decoupling between the PV module(s) and the single-phase grid; 3) whether they utilizes a transformer (either line or high frequency) or not; and 4) the type of grid-connected power stage.

F. Blaabjerg, R. Teodorescu, M. Liserre, and A. V. Timbus,[6] "Overview of control and grid synchronization for distributed power generation systems," This paper gives an overview of the structures for the DPGS based on fuel cell, photovoltaic, and wind turbines. In addition, control structures of the grid-side converter are presented, and the possibility of compensation for low-order harmonics is also discussed. Moreover, control strategies when running on grid faults are treated. This paper ends up with an overview of synchronization methods and a discussion about their importance in the control.

J. M. Carrasco, L. G. Franquelo, J. T. Bialasiewicz, E. Galván, R. C. P. Guisado, M. Á. M. Prats, J. I. León, and N. M. Alfonso,[7] "Power electronic systems for the grid integration of renewable energy sources: A survey," This paper proposes about distributed energy resource is increasingly being pursued as a supplement and an alternative to large conventional central power stations. The specification of a power electronic interface is subject to requirements related not only to the renewable energy source itself but also to its effects on the power-system operation,

III. MODELLING & METHODOLOGY OF PROPOSED SMES BASED DVR –

3.1CONFIGURATION OF DVRThe DVR can be used for protection and recovery or restore the quality of voltage to the sensitive load. Dynamic Voltage Restorer (DVR) is one of the effective custom power devices that can be used to improve power quality from any disturbances in the distribution line A set of three phase voltages with an appropriate magnitude and duration can be injected through injection transformer and must be in phase with the grid voltage. A DVR is a solid state power electronics switching device consisting of either GTO or IGBT, a capacitor bank as an energy storage device and injection transformers

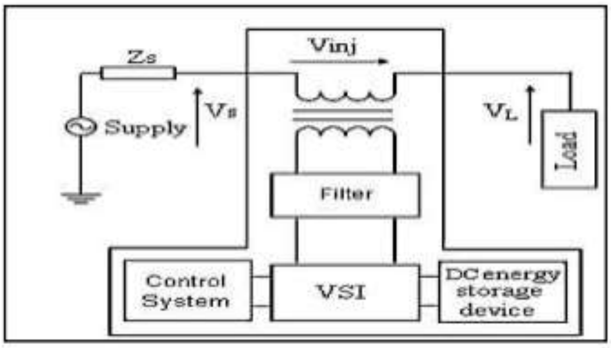

Fig 3.1- Schematic representation of a DVR

3.2 SMES AS ENERGY STORAGE DEVICE OF DVR SMES is the Super Conducting Magnetic Energy System used in DVR as energy storage device.SMES systems have very fast charge and discharge times which make them an attractive energy storage system for sag mitigation. Another advantage of SMES systems is the very low losses due to the superconducting characteristics. It consists of super conducting magnetic energy storage unit, capacitor bank, VSI, low pass filter.It consists of main system and its sub systems. An SMES unit includes of a large superconducting coil, whose temperature is maintained below the cryogenic temperature by a cryostat or Dewar that contains either helium or nitrogen liquid as the coolant. During standby condition, to reduce the energy losses a bypassswitch is used[Finally a transformer which provides the power system connection and co-ordination and PCS operating voltage will reduce to acceptable levels

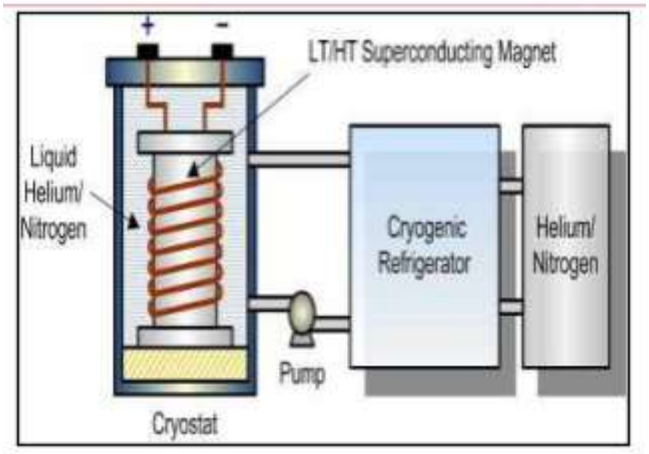

Fig 3.2.1- SMES schematic model

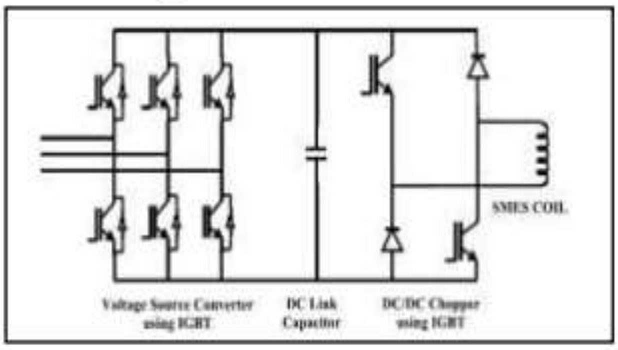

Fig 3.2.2VSC Based SMES model The structural figure 3.2.2 of the SMES unit with VSCbased PCS includes of a star-delta transformer, a basic sixpulse PWM converter with insulated gate bipolar transistor (IGBT) as the switching device, a two quadrant bidirectional dc-dc chopper using IGBT, and an inductor as the superconducting coil. The decoupling of ac/dc converter and the dc-dc bidirectional converter is obtained by a large dc link capacitor.A power electronic link between the ac supply network and the dc current controlled superconducting coil is established by the PWM VSC.The PWM signal is obtained for the switching of IGBT by comparing the reference signal obtained from abc conversion with the high frequency triangular carrier signal. Throughout the operation the dc voltage across the capacitor is kept at its reference value by the six-pulse PWM converter .In our model VSC based SMES is used..

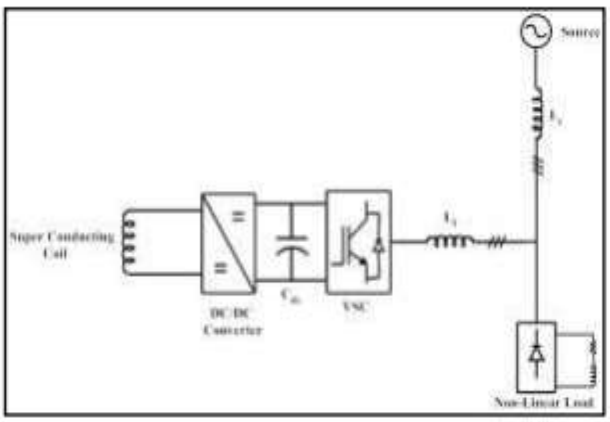

Fig:3.2.3 Proposed System Topology

Here, the PCS consists of a VSC and A DC/DC converter to control the source current as well as the charge-discharge cycle of SMES. DC/DC converter is a simple voltage bidirectional converter consists of IGBTs and diodes . When the switches are „ON" SMES coil gets charged and positive voltage is applied on it; when they are „OFF" negative voltage is applied on it and it discharges through diode. In both modes current remains unidirectional. During standby condition one of the switches is „ON" and current circulates between that switch and one diode. The switching of this is regulated to get a constant dc-link voltage. Here, VSC is a six-pulse conventional full bridge converter. IGBT antiparallel with a diode is used as the switch to get bidirectional current. It is controlled to operate in both rectifying and inverting modes.[20][21] A voltage bidirectional dc-dc chopper is used to regulate the charge-discharge of the superconducting coil. The dc-dc chopper is controlled to make the voltage across SMES coil such as positive (IGBTs are switched ON) or negative (IGBTs are switched OFF) and then the energy reserved in SMES can be supplied or consumed accordingly. Hence, the charging and discharging of superconducting coil depends on the average voltage per cycle across the coil that is calculated by the duty cycle of the two-quadrant chopper. In order to obtain thePWM gate pulses for the IGBTs of the dc/dc converter, the estimated signal is compared withthe triangular/saw-toothed carrier signal .[21]. The applied voltage across SMES coil is controlled by regulating the conduction time of the IGBT over the switching cycle. While the duty cycle is 0.5, average voltage across the SMES coil and average DC current in the VSC are both zero, and net power transferred throughout one complete switching cycle is zero. For a duty cycle larger than 0.5, the coil gets charged; while at less than 0.5, the coil gets discharged. Therefore, the control of charge/discharge is established by regulating the duty cycle of the switching devices.

3.3 PRINCIPLE OF OPERATION OF SMES

Principle of Operation-The systems works on the principle of energy balance between sources, load and SMES coil. The source current can be described as

$$I_s = I_l \pm I_i$$

Where Is= Source Current Il= Load Current Ii= Inverter Current

The output current of inverter is

$$I_i = f(I_o, D, M)$$

Where Io= SMES coil current

D = Duty cycle of dc/dc converter M = Modulation index of inverter

Under load leveling condition the source current charges the coil when load power is less then source power. When, there is an increase in load occurs source power increases withload to its maximum and coil discharges to make energy balance between source, load andSMES. In the whole operation dc link voltage is kept constant

IV. CONCLUSION

this paper, a voltage sag enhancement of sensitive loadwhich gets power from grid connected PV-wind powersystem is demonstrated using HES based DVR. Thenproposed DVR targets to protect the sensitive load frombeing affected by any voltage fluctuation which arise either from fault condition or unstable power output of PV-windsystem. The control and operations of BES and SMESdevices is developed by observing voltage condition of thegrid at the PCC and the SOC levels of battery and SMES. Inaddition to this, for full realization of the proposed DVRsystem the control and operation of the VSC is developed byobserving the voltage level at the PCC. The pre-sagcompensation strategy is selected based on the capability ofboth magnitude and phase jump restoration. Based on theconditions, three operating states of the HES based DVR aredefined, which are normal (idle state), charging state anddischarging state. The effectiveness of the proposedoperating states has been demonstrated in realistic cases. Inthe simulation, different voltage sag depth scenarios areconsidered for both symmetrical and asymmetrical voltageimbalances and the HES based DVR works well

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