Regulation Technique For Voltage Sag and Swell Using Dynamic Voltage Restorer

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Abstract - Power quality is one of big concerns in the recent era. It has become very special, mostly, with the introduction of devices, whose function is more sensitive to the quality of power supply. Power quality problem is the occurrence of the nonstandard current, voltage or frequency that results in a failure of end use devices This paper presents the application of superconducting magnetic energy storage based dynamic voltage restorers (DVR) on power systems for mitigation of voltage sags/swells at critical loads by using super magnetic energy source Simulation results are given to illustrate and understand the function of DVR in supporting load voltages under voltage sags/swells situations.

Keywords - Voltage sag, power quality, voltage swell ,harmonic, SMES based DVR.

1. INTRODUCTION

Power quality and reliability in distribution and transmission systems had been an increasing popularity in modern conditions and become an area of concern for modern commercial and industrial and domestic applications. Introduction to main and efficient systems, industrial applications , electronic devices in modern times demands good quality and reliability of power supply in distribution as well as in commercial networks . Power quality problems consists of a wide range of phenomena. Voltage sag and swell, flicker, harmonics distortion, impulse transients and interruptions are very prominent few. These disturbances are responsible for errors to plant shut down and loss of manufacturing capability. Voltage sags and swells occur most frequently than any other power quality problems. These sags and swells are the most important power quality problems in the power distribution system and transmission system In order to overcome these challenges, it needs a element which is capable for injecting minimum energy so as to regulate load voltage at its nominal value. Dynamic Voltage Restorer (DVR) is one of the effective methods for compensating the power quality problems such as voltage swells and sag. SMES based Dynamic voltage restorer (DVR) can provide an effective solution to mitigate voltage sag and swell by injecting the appropriate voltage level required by the loads. It is also used as the active solution for voltage sag and swell mitigation in modern industrial and commercial applications In this paper, a new configuration of SMES based Dynamic Voltage Restorer (DVR) is used which is capable of regulating power quality problems associated with voltage swells and sags and maintained a prescribed level of supply voltage at the different load points .SMES is nothing but the supermagnetic energy storage which consists of supermagnetic coils .The simulation of the smes based DVR is accomplished using MATLAB/ SIMULINK

1.1The Custom Power Concept

The concept of custom Power was introduced by N.G. Hingorani in 1995 in the U.S.A. Like Flexible AC Transmission Systems (FACTS) for transmission systems.The word custom power accounts to the use of power electronics controllers in a distribution system, especially, to deal with different power quality problems. Just as FACTS improves the power transfer capabilities and stability margins, custom power give sureity to customers to get pre-specified quality and reliability of supply. This maintained quality may contain a combination of specifications of the following , low phase unbalance, no power interruptions, low flicker at the load voltage,magnitude without significant effect on the terminal voltage.

2. POWER QUALITY

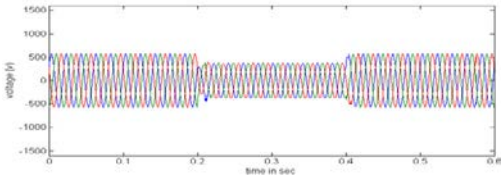
Since the discovery of electricity 400 years ago, the generation, transmission and distribution and use of electricity had evolved steadily. New and innovative ideas means to generate and use electricity fuelled the industrial revolution and since then the scientists and engineers have been researched to its continuing evolution. In the beginning of revolution , electrical machines and devices consumed large amounts of electricity . The machines were designed with low cost concerns and secondary to better performance considerations. However, in the last 60 years, the industrial age would led for need for products to be effectively and economically competitive. Increased demand for electricity have created extremely used of power in generation and distribution systemA power

quality problem is defined as any manifested problems related to voltage or current or frequency variations that result in mis-operation of customer devices. Power qualities have serious issue not only for the consumers but also for the distributors. Power system, especially the distribution system and transmission system , have numerous non-linear loads which significantly affects the quality of power supply. These loads might be distroy the supply waveform. Some system also have power quality problems like capacitor switching, starting of motors and faults. The power quality problems includes a large economic loss

2.2 Power Quality Problems

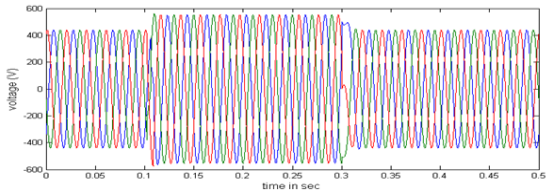
2.2.1 Voltage sag

A voltage sag as defined by IEEE standard 1159-1995 IEEE recommended practice for monitoring electric power quality which is a reduction in rms voltage at the power frequency for durations from 0.5 cycles to 1 minute reported as the remaining voltage.



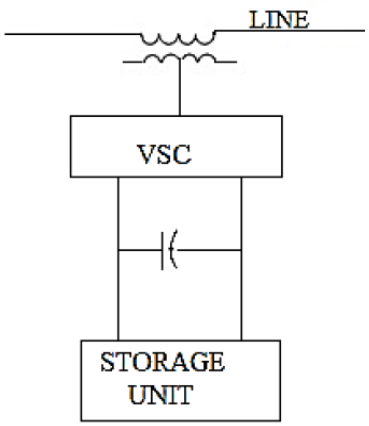
3.2.2 Voltage Swells

Voltage Swell is defined by IEEE 1159 as the increase in the rms voltage level to 110%-180% of nominal, at the power frequency for durations of ½ cycles to one minute.



4. DYNAMIC VOLTAGE RESTORER/ REGULATOR (DVR)

The series voltage controller is connected in series with the load as shown in Figure A DVR is a device that injects a dynamically controlled voltage V in series to the bus voltage connecting to booster transformer as depicted in Figure L There are three single phase booster transformers which are connected to a three phase converter with energy storage system and control circuit . The value of the three injected phase voltages are controlled such as to eliminate bus fault to the load voltage V1. This means that any differential voltage occurred by transient errors will be regulated by an equivalent voltage generated by the converter and injected through the booster transformer. The DVR does not work dependently of the type of fault so that the whole system remains connected to the supply system, i.e. the line breaker does not trip The main advantage of this method is that a one DVR may be installed to protect a whole plant (a few MVA) as well as single loads. Because of the IGBT's like fast switches, voltage regulation can be achieved in less than half a cycle



4.1Basic Configuration of DVR:

The basic configuration of the DVR consists of:

1. An Injection/ Booster transformer

2. A Harmonic filter

3. Storage Devices

4. A Voltage Source Converter (VSC)

5. DC charging circuit

1 Injection/ Booster transformer:

The Injection or Booster transformer is a especially designed transformer that try to limit the coupling of noise and transfer energy from the primary side to the its secondaryThe DVR is made of solid-state dc to ac switching power converter or inverter, mainly a voltage source converter (VSc) that injects ac output

2 Harmonic Filter:

Usually, a filter unit consists of inductor and capacitor. Filter attempts to eliminate the unwanted harmonic elements produced by the voltage source converter.

3 Storage Device:

The purpose of storage devices is to give the required energy energy to the VSC through the link of dc to have the generated voltages. There are different kinds of energy storage devices are batteried ,capacitance and Superconductive magnetic energy storage (SMES).

4 Voltage Source Converter:

A VSC is a power electronic system consists of a switching device and storage devices, which can give a sinusoidal voltage at per the phase angle, magnitude, and frequency. In the DVR function , the VSC is used for replacememt of temporarily supply voltage or to regulate part of the supply voltage which is missing.

voltages in series to be synchronism with the distribution system voltages. The input terminal of dc of the DVR is connected to an energy storage device of appropriate capacity.

5. SUPERMAGNETIC ENERGY STORAGE (SMES)

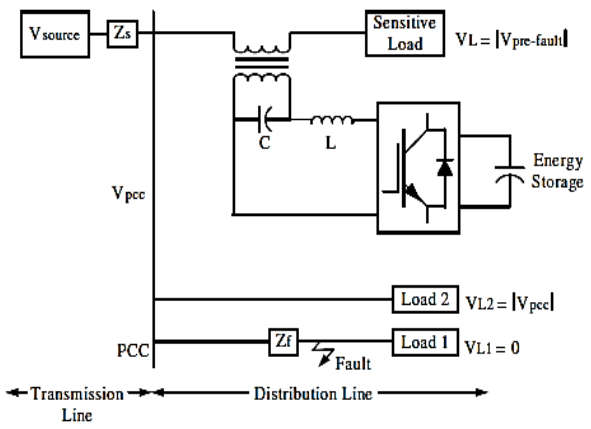
The power conditioning system uses a rectifier to transform alternating current power to direct current or vice versa The inverter or rectifier relates for about 2–3% energy loss in each particular directions. SMES lost the at least amount of electricity in the energy storage process compared to other methods for storing energy. SMES is highly effective system,the round-trip efficiency is greater than 95%

5.1 Configuration of SMES

The voltage source converter performs as storage device linking the SMES coil to the grid. It produced the values of direct and quadrature axies by comparing the given value of the DC link voltage and load voltage to their base values. This gives as an input signal to the voltage source converter. PWM converter performs the operation for maintaining the voltage across DC link capacitor to be constant

6. LOCATION OF A SMES BASED DVR

If a fault occurs on the line feeding load 1 then its voltage reaches to zero. Load 2 experiences voltage sag condition whose magnitude is as equal as to the load voltage at the point of common coupling



7.Voltage Injection Techniques

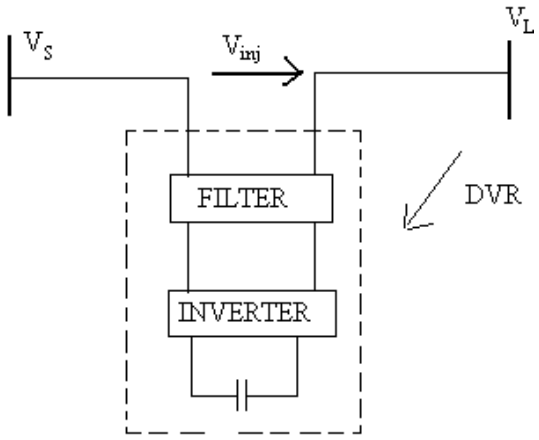
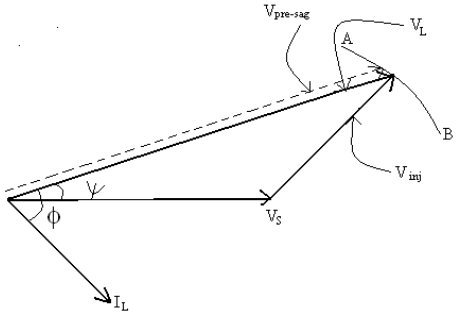


Figure 7 Block Diagram of Series compensation method

Fig.7 shows the basic topology of DVR connected in series with the system. V_S denotes the source voltage, VLdenotes the load voltage and V_{inj} is the voltage injected by the DVR

7.1 Pre-sag Compensation Technique

Some voltages are sensitive not only to rms value of the load but also to the phase of load voltage. In this case, illustrated in the Fig.7.1, DVR injects voltage such that the compensated load voltage is in the phase with pre-sag voltage.



The minimum source voltage that can be boosted to V_{nom} is

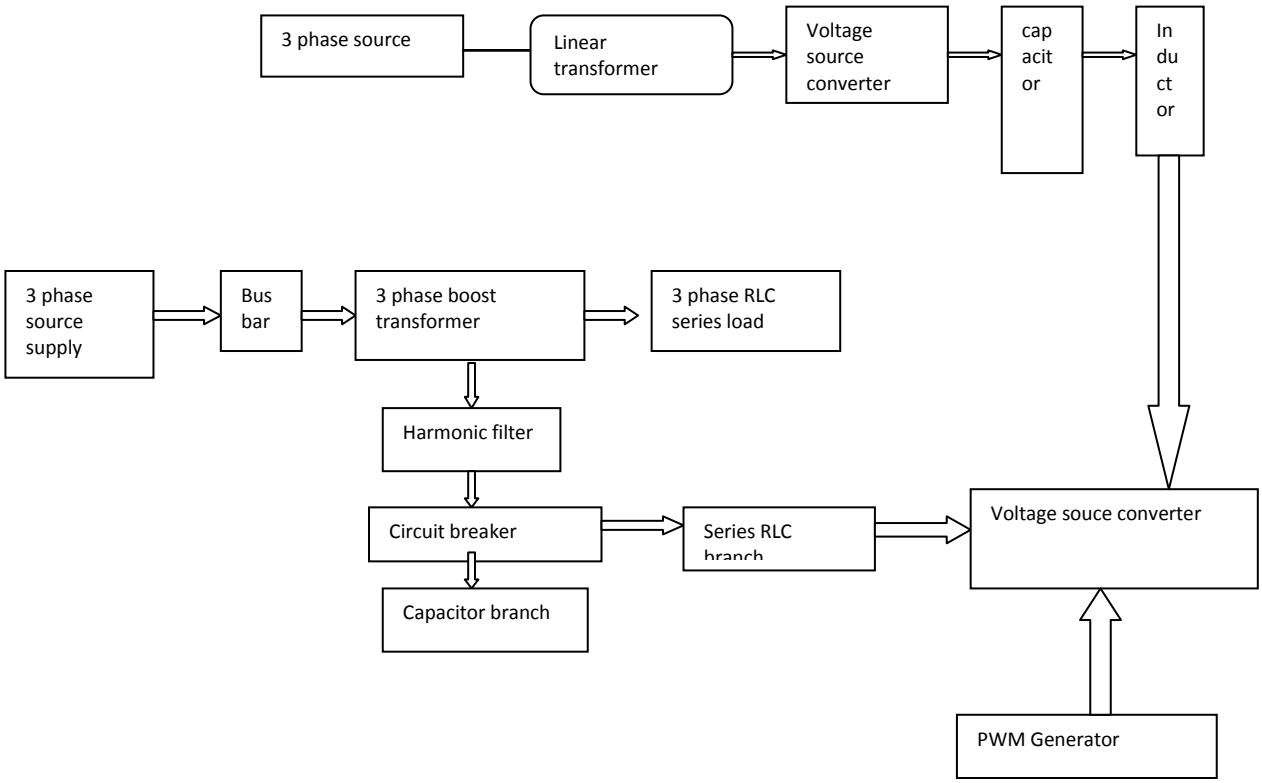
$$\left|V_S^{\min}\right| = \left|V_{nom}\right|.\cos\Psi - \sqrt{\left(\left|V_{inj}\right|^2 - \left|V_{nom}\right|^2 \sin^2\Psi\right)}$$

Where,

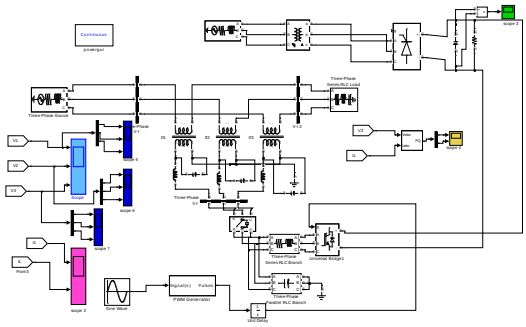
V_{inj} is the maximum injection capability of the DVR.

This technique also requires active power from the DVR, so load power factor affects the duration that the DVR can maintain the load bus voltage at V_{nom}.

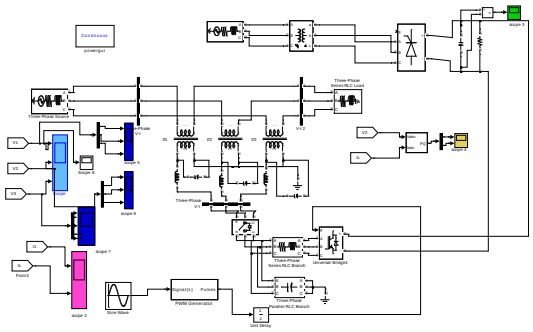
Block diagram of simulink model of SMES based DVR



1.Simulation for voltage sag



2 Simulink model for voltage swell with RL load



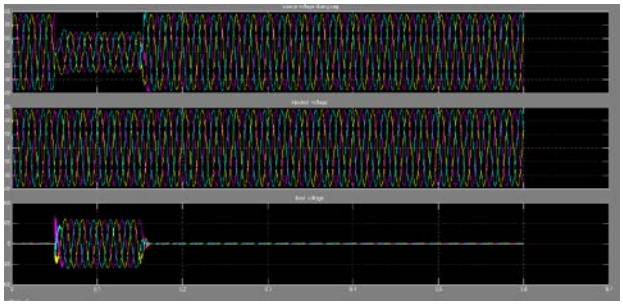
8. MODELLING OF SMES BASED DVR

The compensation of voltage sag and swell may be controlled by a numbers of factor, including smes based DVR power rating, loading conditions. If a DVR is a successful device, the control is able to regulate most sags and swells and the performance is simulated by using MATLAB tool.

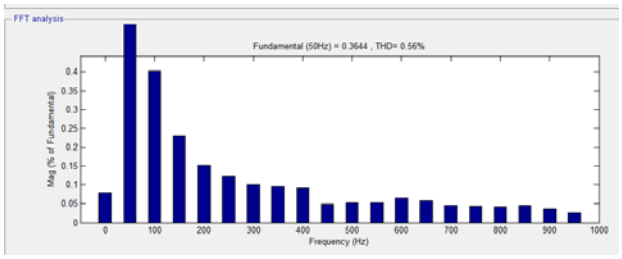
9. RESULTS

9.1 For voltage sag

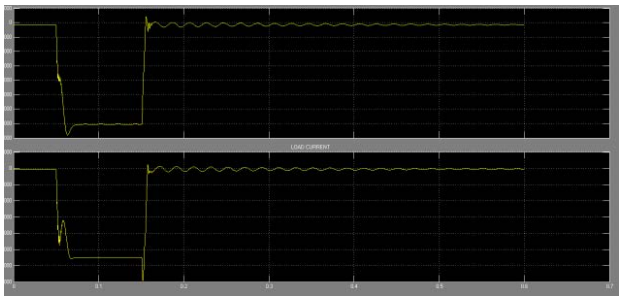
Symmetrical sag is simulated by connecting a three-phase reactance in series with resistance to the bus bar. In this the 40 % sag is initiated at 50ms and it is kept until 150ms, with total voltage sag duration 100ms.the modulation of dvr is observed the Modulation Timing [Ton Toff]= [0.15 0.25]In this simulation the sag is almost corrected. Here, 99% sag is corrected in each phase. When sag is occurred the DVR automatically comes into the action.



THD for voltage sag is 0.56%

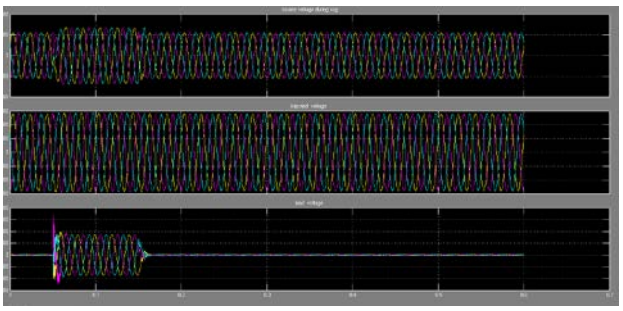


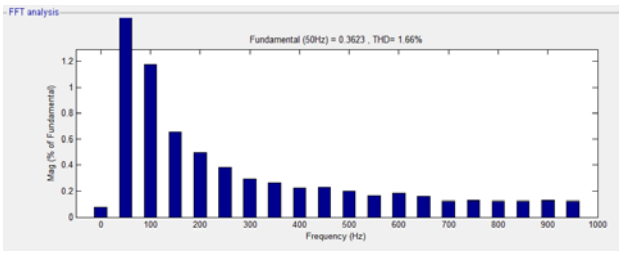
Real and reactive power is shown below



9.1 For Voltage Swell With Rlc Load

The performance of DVR for a voltage swell condition is observred..Voltage swell is occured by energizing of a large capacitor bank and supply voltage is shown in Figure. The voltage amplitude is increased about l25o/o of nominal value. The load voltage and the injected voltage, are shown in Figure





THD for voltage swell is 1.66%

10. CONCLUSION

It was observed that is the voltage sag and swell are regulated in series with the system, the harmonic component of isvery lowand the total harmonic distortion is within 2%.The DC side capacitor voltage can be maintained about 400 V,. The duration of voltage sag is 0.1 s, and the magnet delivers about 781.25 J of energy

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