Parasitic Boost Circuit for Transform Less Active Voltage Quality Regulator

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Abstract **- The voltage sag compensator, based on a series-connected voltage-source inverter, is among the most cost-effective solution against voltage sags. When voltage sags happen, the transformers, which are often installed in front of critical loads for electrical isolation, are exposed to the disfigured voltages and a dc offset will occur in its flux linkage. In this paper, a new topology of series-connected compensator is presented to mitigate long duration deep sags, and the compensation ability is highly improved with a unique shunt converter structure acting as a parasitic boost circuit that has been theoretically analyzed using open loop & closed loop control schemes. Additionally, the proposed active voltage quality regulator is a cost effective solution for long duration sags that are lower than 50% of the nominal voltage as it is transformer less compared with the traditional dynamic voltage restorer. a new topology of series-connected compensator is presented to mitigate long duration deep sags, and the compensation ability is highly improved with a unique shunt converter structure acting as a parasitic boost circuit that has been theoretically analyzed.**

Keywords: Dynamic Voltage Restorer (DVR), Dynamic Sag Correction, Long Duration Deep Sag, Parasitic Boost Circuit, Series Connect Compensator.

I. INTRODUCTION

Electronic devices function properly as long as the voltage (or driving force) of the electricity feeding the device stays within a consistent range. There are several types of voltage fluctuations that can cause problems, including surges and spikes, sags, harmonic distortions, and momentary disruptions. Voltage sag is not a complete interruption of power; it is a temporary drop below 90 percent of the nominal voltage level. Most voltage sags do not go below 50 percent of the nominal voltage, and they normally last from 3 to 10 cycles—or 50 to 170 milliseconds.

Voltage sags are probably the most significant power quality (PQ) problem facing industrial customers today, and they can be a significant problem for large commercial customers as well. There are two sources of voltage sags: external (on the utility's lines up to your facility) and internal (within your facility). Utilities continuously strive to provide the most reliable and consistent electric power possible. In the course of normal utility operations, however, many things can cause voltage sags. Storms are the most common cause of external sags and momentary interruptions in most areas of the U.S. A storm passing through an area can result in dozens of major and minor PQ variations, including sags. For example, consider how PQ would be affected by a lightning strike on or near a power line or by wind sending tree limbs into power lines. Other common causes of external voltage sags are ice storms, animals (particularly squirrels), and the start-up of large loads at neighbouring facilities. Internal causes of voltage sags can include starting major loads and grounding or wiring problems.

If your facility is having frequent voltage sag problems, a good place to start is with your utility. Ask about the utility's statistics regarding performance in your area. You should also look into possible internal causes. But whether the causes are mainly external or internal, you should consider taking charge of the problem and working toward a cost effective solution for your facility. This obtained novel topology is called the transformer less active voltage quality regulator with the parasitic boost circuit (PB-AVQR), and it is capable of mitigating long duration deep voltage sags without increasing the cost, volume, and complexity compared with the traditional DySC topology.

This paper starts with introducing the operating mode and working principles of the proposed configuration. Then, the parasitic boost circuit model is provided followed by the theoretical analysis to calculate its dc-link voltage. As shown in Fig. 1, the PB-AVQR topology is mainly consists of five parts, including a static bypass switch (VT1, VT2), a half-bridge inverter (V1, V2), a shunt converter (VT3, VT4), a storage module(C1,C2), and a low-pass filter (Lf , Cf).The operating mode and applied control strategies are similar to what have been described.

II. PROPOSED PB-AVQR TOPOLOGY

Under normal operating conditions, the static bypass switch is controlled to switch on and the normal grid voltage is delivered directly to the load side via this bypass switch. When an abnormal condition is detected, the static bypass switch will be switched OFF and the inverter will be controlled to inject a desired missing voltage in series with the supply voltage to ensure the power supply of sensitive loads. There are totally two different kinds of control strategies in the proposed PBAVQR system. When the grid voltage is lower than the rated voltage, an in-phase control strategy will be adopted and a phase-shift control strategy will be applied when the supply voltage is higher than the nominal voltage.

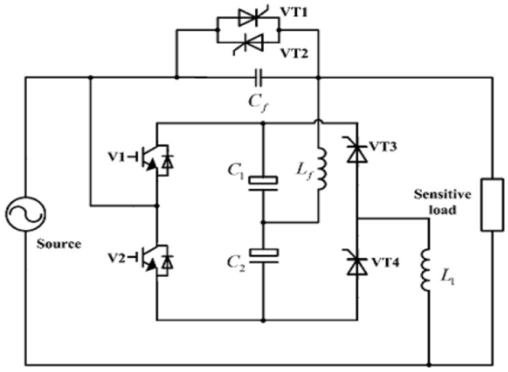

Fig: 1 Proposed PB-AVQR topology.

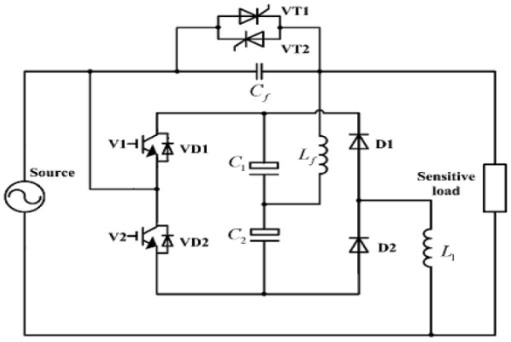

Fig 2 SPB-AVQR Topology.

So, the compensation ability of the SPB-AVQR is theoretically unlimited as long as the grid is strong enough to provide the needed power. However, as the boost circuit is parasitic on the series inverter, and the two switches are actually controlled according to the missing voltage, there still exist some restrictions. The relationships between the dc-link voltage and other system parameters will be discussed in the next section. Parts of the waveforms obtained at the inverter side and load side under four operating conditions are schematically shown in Fig.3, where UaN represents the voltage between a and N. So, the load voltage will be maintained at its rated value if the inverter is properly controlled according to the required missing voltage during sags.

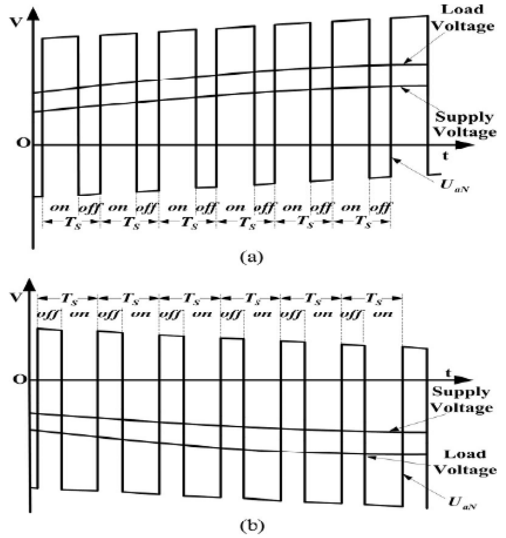

Fig 3 Waveforms of supply voltage, load voltage, and *UaN* . (a) V2 on/off. (b) V1 on/off.

III. MATLAB/SIMULINK RESULTS

Matlab/Simulink Model of DySC Topology by using Matlab/Simulink platform as shown in Fig.4.

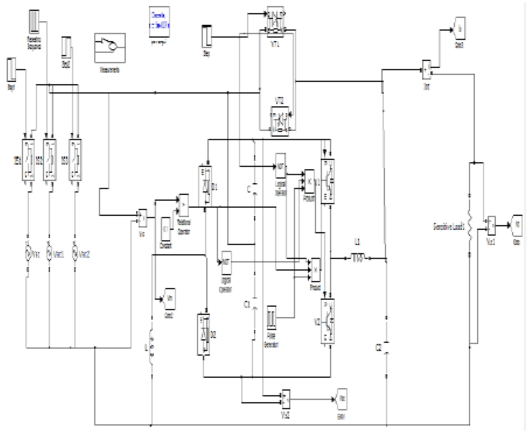

Fig.4. Matlab/Simulink Model of DySC Topology by using Matlab/Simulink

Fig. 5 shows the simulation results of the DySC topology voltage drops to 180 V at 0.1 s and then falls to 100 V at 0.4 s, when the supply voltage is 180V, the DySC can effectively compensate for the voltage sag; however, when the supply voltage drops to 100 V, the load voltage becomes not sinusoidal as the maximum injected compensation voltage is limited by the low steady-state dc-link voltage. Fig. 10 also indicates that the DySC can only mitigate deep sags for a few line cycles depending on the energy stored in dc-link capacitors as its steady-state dc-link voltage is always lower than the peak value of the supply voltage.

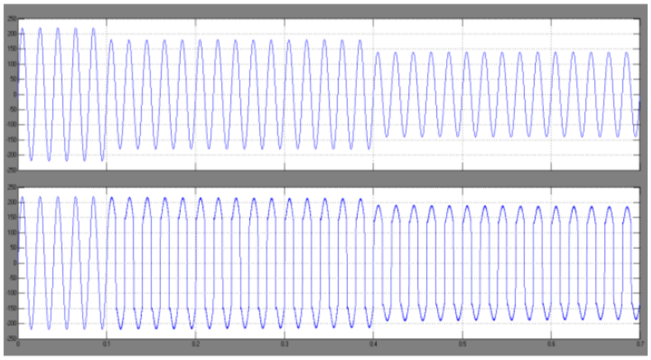

Fig:5 Supply Voltage & Load Voltage of DySC Topology.

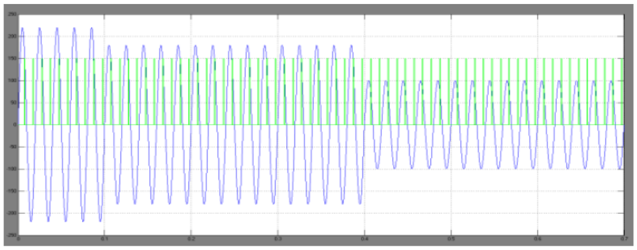

Fig:6 Input Voltage & Switching States

Proposed Active Voltage Quality Regulator Topology with Closed Loop Controller wave forms as shown in Fig.6.

CONCLUSION

This paper has presented a novel transformer less active voltage quality regulator with parasitic boost circuit operates under closed loop condition to mitigate long duration deep voltage sags with good stability factor and low error components. The proposed PB-AVQR topology is derived from the DySC circuit and the compensation performance is highly improved without increasing the cost, weight, volume, and complexity. It is a relatively cost-effective solution for deep sags with long duration time compared with the traditional DVR topology with load-side-connected shunt converter as a series transformer is no longer needed. The working principle and circuit equations are given through theoretical analysis. The operating efficiency of the proposed PB-AVQR system also remains at a relatively high level as the dc-link voltage adaptive control method is adopted.

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