Ultracapacitor Connected Flexible AC Distribution System Device

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Abstract - Power quality is often defined as the electrical grid's competency to supply an unsullied and stable power supply. In other words, power quality ideally engenders an impeccable power supply that is always available and is within voltage and relative frequency tolerance. Performance of Flexible AC Distribution System Device using ultracapacitor for the power quality improvement is proposed in this paper. In this paper, ultracapacitor is connected to the dc-link of the power conditioner through a bidirectional dc–dc converter that service in providing the dc-link voltage. The integration avails in providing sag and swell emolument. The simulation model of the overall setup is developed in MATLAB.

Keywords – VSC; Flexible AC Distribution System Device; shunt inverter; series inverter; DVR;APF

I. INTRODUCTION

THE concept of micro grid has offered consumers with increased reliability and reduction in total energy losses, and has become a promising alternative for traditional power distribution system [1].

A micro grid can operate independently or in conjunction with the area's main electrical grid on a small scale. One area of work for the connection of a micro gridiron to the distribution grid is the encroachment of power caliber (PQ) problems on the overall power system execution. Some of the problems include voltage and frequency distractions in the grid. To surmount the aforementioned PQ quandaries, several power-conditioning devices such as Dynamic Voltage Restorer [3],Uninterruptible Power supply [5], Static VAR Compensator(SVC) and APF [4] are customarily employed by consumers to forefend their loads and systems against PQ perturbances in the distribution network.

A nonlinear load causes many power character problems like high electric current harmonic, voltage and frequency deviations, low power factor. Nonlinear stacks appear to be current sources injecting harmonic current into the supplying network through the utility's Point of Coupling (PCC).This results in distorted voltage drop across the source impedance, which causes voltage distortion at the PCC. Other customers at the same PCC will receive distorted supply voltage, which may cause overheating of power factor correction capacitance, transformers and cables ,motors and faulty function of some protection devices. By the combination of series and shunt Voltage Source Inverter, a Flexible AC Distribution System Device is realized which is installed at the Point of Common Coupling of the statistical distribution power system that the micro grid and other electrical loads are connected which helps in the betterment of the power quality problems. Flexible AC distribution system device consists of the ultracapacitor to store the excess energy generated and to provide power during islanding of the grid.

The complete inverter control algorithm is based on the DSP TMS320F28335. The series inverter is responsible for compensating the voltage sags and swells whereas the shunt inverter is responsible for active/reactive power support and renewable intermittency smoothing. The shunt inverter controller implementation is based on the id - iq method and the series inverter controller implementation is based on the in-phase compensation method [2]. By incorporating this method it helps in the betterment of the device as it has a versatile control over voltage sag and swell as well as active and reactive power support. The following areas are addressed by this device: (1) Sag compensation (2) Swell compensation when there is a disturbance in the grid (3) Grid Islanding condition when there is a fault.

II. System Description: Three Phase Inverters

A. Power System –

Two back-to-back three-phase voltage source inverters connected through a dc-link capacitor acts as the power source. ultracapacitor stockpiling is associated with the dc-join capacitor through a bidirectional dc–dc converter. The series inverter is in charge of repaying the voltage droops and swells; and the shunt inverter is in charge of active/reactive power support and renewable discontinuity smoothing. The inverter systems consist of IGBT module, gate-driver, LC filter and an isolation transformer. The dc-link voltage Vdc is directed for ideal voltage and current remuneration of the converter and the line–line voltage is Vab. The goal of this project is to provide the system with active power capability 1) to compensate temporary voltage sag and swell, and 2) to provide active/reactive support and renewable intermittency smoothing, which is in the seconds to minutes time scale[2]. The complete block diagram of the series DVR, shunt APF, and the bidirectional dc–dc converter is shown in Fig. 1[2].

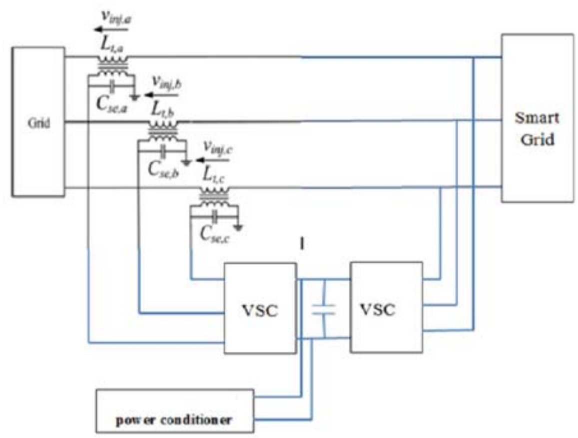


Figure 1. Block diagram of Flexible AC Distribution System Device using ultracapacitor integrated Power Conditioner [2]

B. Controller Execution –

The series inverter controller usage depends on the in-phase compensation technique that requires PLL for assessing θ, and this has been executed utilizing the fictitious power strategy portrayed in [2]. In light of the assessed θ and the line–line source, voltages Vab, Vbc, Vca (which are accessible for this delta-sourced framework) are changed into the d–q space and the line–neutral segments of the source voltage Vsa, Vsb, and Vsc which are not accessible can then be evaluated from the mathematical statements [2]. The entire execution is same as in [2] with variety in the bus design.

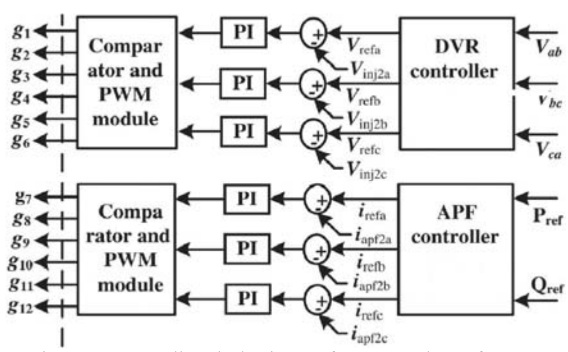


Figure 2. Controller Block Diagram for DVR and APF from [2]

III. Converter

C. Bidirectional DC-DC Converter and controller

A bidirectional dc–dc converter is required as an interface between the ultracapacitor and the dc-join, following the voltage changes with the measure of vitality released, while the dc-join voltage must be stiff.. The dc–dc converter ought to work in Discharge mode, while giving active/reactive power backing and voltage droop remuneration. The dc–dc converter ought to likewise have the capacity to work in bidirectional mode to have the capacity to charge or assimilate extra power from the framework amid discontinuity smoothing. In this paper, the bidirectional dc–dc converter goes about as a boost converter, while releasing force from the ultracapacitor and goes about as a buck converter while charging the ultracapacitor from the matrix. Average current mode control, most stable[2], is widely used to regulate the output voltage of the bidirectional dc–dc converter in both Buck and Boost modes while charging and discharging the ultracapacitor. Controller block diagram is shown in Fig. 2, where the actual output voltage Vout is compared with the reference voltage Vref and the error is passed through the voltage compensator that generates the average reference current[2].

III. EXPERIMENT AND RESULT

The Flexible AC Distribution System Device is tested for different test case. The simulation results waveforms in MATLAB are obtained and are as follows.

A. Test Case 1:Sag Compensation

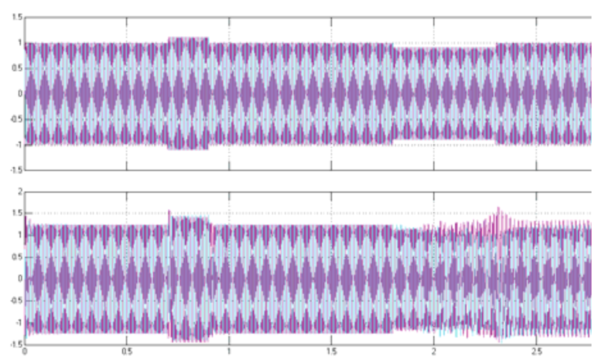
The device is designed to deal with the sag such that it is auto corrected within few seconds. The sag in the voltage and current waveform($1.8 < t < 2.3$s) near the load is seen and the same is picked in few cycles as in fig 3.

B. Test Case 2: Swell Compensation

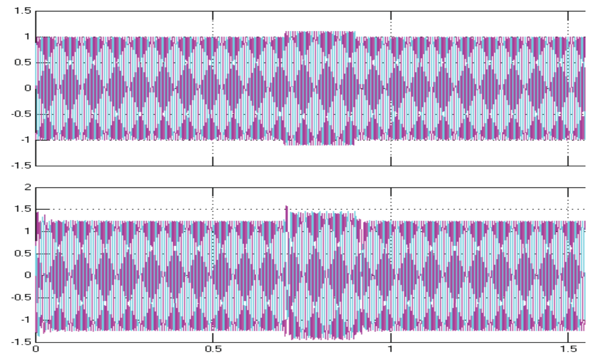
The device is designed to deal with the swell such that it is auto corrected within few seconds. The swell in the voltage and current waveform($0.7 < t < 0.9$ s) near the load is seen and the same is picked in few cycles as in fig 4.

C. Test Case 3:Grid Islanding Condition

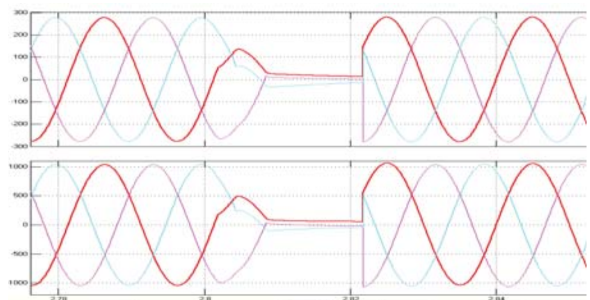
When a fault occurs the grid gets isolated. The same is seen in fig.5. The grid gets disconnected to protect the loads during fault. The ultracapacitor in the meanwhile supplies power such that the cycle is picked in the next cycle.



(a)



(b)



(c)

Figure 3. (a) Voltage and Current waveform during sag from 1.8 to 2.3s. (b) Voltage and Current waveform during swell from 0.7 to 0.9. (c) Grid Islanding condition

IV.CONCLUSION

This paper proposes Flexible AC Distribution device integrated with a ultracapacitor to store the excess energy accumulated. The same would be used when there is a disturbance in the grid. This device helps to compensate the sag and swell condition. By using this device Power Quality problems can be minimized. The simulation results provide satisfactory performance of the device. Further investigations can be made to check for other dynamic conditions of the grid.

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