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Power Quality Improvement using Ultracapacitor as Integrated Power Conditioner

[1]G.Vasundhara, [2]P.Sarala,

[1]PG Scholar Electrical Power Systems, Dr.K.V.Subba Reddy College Of Engineering For Women,

[2]HOD Dept Of EEE, Dr.K.V.Subba Reddy College Of Engineering For Women.

Abstract:
Penetration of various types of distributed energy resources (DERs) like solar, wind, and plug-in hybrid electric vehicles (PHEVs) onto the distribution grid is on the rise. There is a corresponding increase in power quality problems and intermittencies on the distribution grid. In order to reduce the intermittencies and improve the power quality of the distribution grid, an ultracapacitor (UCAP) integrated power conditioner is proposed in this paper. UCAP integration gives the power conditioner active power capability, which is useful in tackling the grid intermittencies and in improving the voltage sag and swell compensation. UCAPs have low energy density, high-power density, and fast charge/discharge rates, which are all ideal characteristics for meeting high- power low-energy events like grid intermittencies, sags/swells.

Keywords: DER, UCAP, Sag and swells.

1. INTRODUCTION

Power quality is major cause of concern in the industry, and it is important to maintain good power quality on the Therefore, there is renewed interest in power quality products like the dynamic voltage restorer (DVR) and active power filter (APF). DVR prevents sensitive loads from experiencing voltage sags/swells and APF prevents the grid from supplying non sinusoidal currents when the load is nonlinear. The concept of integrating the DVR and APF through a back– back inverter topology was first introduced in and the topology was named as unified power quality conditioner (UPQC).

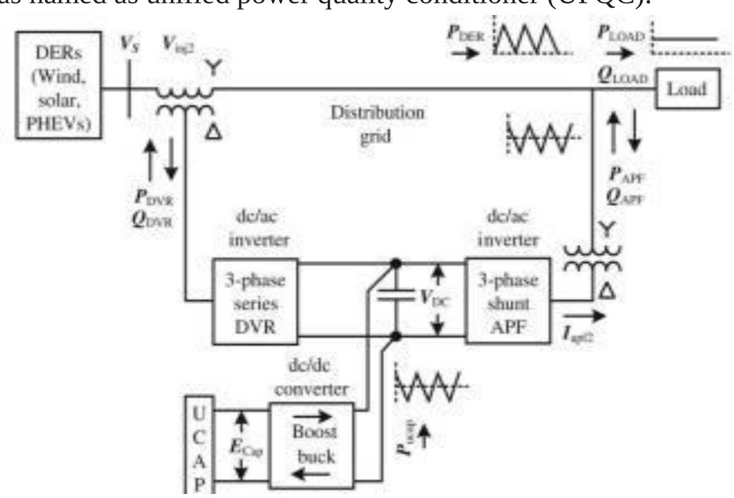

Fig.1.one line structure

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The design goal of the traditional UPQC was limited is paper, energy storage integration into the power conditioner topology is being proposed, which will allow the integrated system to provide additional functionality. With the increase in penetration of the distribution energy resources (DERs) like wind, solar, and plug-in hybrid electric vehicles (PHEVs), there is a corresponding increase in the power quality problems and intermittencies on the distribution grid in the seconds to minutes time scale . Energy storage integration with DERs is a potential solution, which will increase the reliability of the DERs by reducing the intermittencies and also aid in tackling some of the power quality problems on the distribution grid.

2. RELATED WORK

Applications where energy storage integration will improve the functionality are being identified, and efforts are being made to make energy storage integration commercially viable on a large scale. Smoothing of DERs is one application where energy storage integration and optimal control play an important role. Super capacitor and flow battery hybrid energy storage system are integrated into the wind turbine generator to provide wind power smoothing, and the system is tested using a real-time simulator. Super capacitor is used as auxiliary energy storage for photovoltaic (PV)/fuel cell, and a model-based controller is developed for providing optimal control. a battery energy storage system-based control to mitigate wind/PV fluctuations is proposed. Multi objective optimization method to integrate battery storage for improving PV integration into the distribution grid is proposed theoretical analysis is performed to determine the upper and lower bounds of the battery size for grid-connected PV system's rule-based control is proposed to optimize the battery discharge while dispatching intermittent renewable resources. Optimal sizing of a zinc bromine-based energy storage system for reducing the intermittencies in wind power is proposed. It is clear from the literature that renewable intermittency smoothing is one application that requires active power support from energy storage in the seconds to minutes time scale. Reactive power support is another application which is gaining wide recognition with proposals for reactive power pricing. Voltage sag and swells are power quality problems on distribution grid that have to be mitigated.

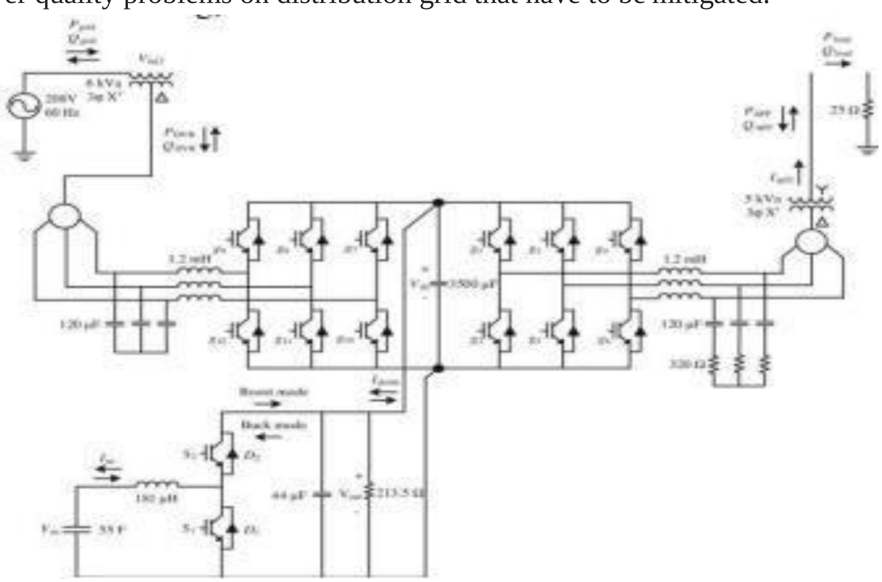

Fig.2.Model of system

3. IMPLEMENTATION

It can be seen that with growing line length, the opportunity for FACTS devices gets more and more important. The influence of FACTS-devices is achieved through switched or controlled shunt compensation, series compensation or phase shift control. The devices work electrically as fast current, voltage or impedance controllers. The power electronic allows very short reaction times down to far below one second. Ultra capacitors are not as volumetrically efficient and are more expensive than batteries but they do have other advantages over batteries making the preferred choice in applications requiring a large amount of energy storage to be stored and delivered in bursts repeatedly.

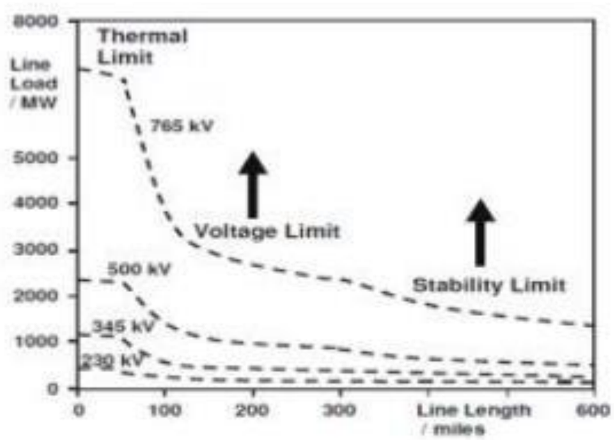

Fig.3.Operational limits

The most significant advantage super capacitors have over batteries is their ability to be charged and discharged continuously without degrading like batteries do. This is why batteries and super capacitors are used in conjunction with each other. The super capacitors will supply power to the system when there are surges or energy bursts since super capacitors can be charged and discharged quickly while the batteries can supply the bulk energy since they can store and deliver larger amount energy over a longer slower period of time. The development of FACTS-devices has started with the growing capabilities of power electronic components. Devices for high power levels have been made available in converters for high and even highest voltage levels. The overall starting points are network elements influencing the reactive power or the impedance of a part of the power system. The term 'dynamic' is used to express the fast controllability of FACTS-devices provided by the power electronics. This is one of the main differentiation factors from the conventional devices.

4. ANALYSIS

The first step in reducing the severity of the system sags is to reduce the number of faults. From the utility side, transmission-line shielding can prevent lighting induced faults. If tower-footing resistance is high, the surge energy from a lightning stroke is not absorbed quickly into the ground. Since high tower-footing resistance is an import factor in causing back flash from static wire to phase wire, steps to reduce such should be taken. The probability of flashover can be reduced by applying surge arresters to divert current to ground. Tree-trimming programs around distribution lines are becoming more difficult to maintain, with the continual reductions in personnel and financial constraints in the utility companies. While the use of underground lines reduces the weather-related causes, there are additional problems from

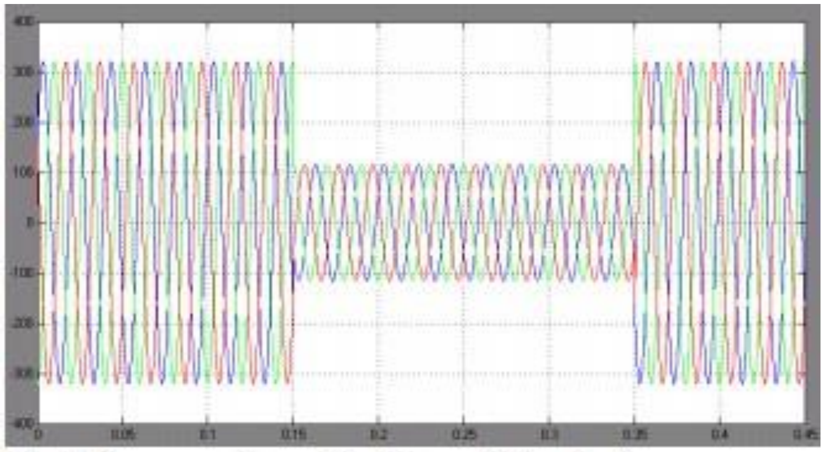

Fig.4.Wave Analysis

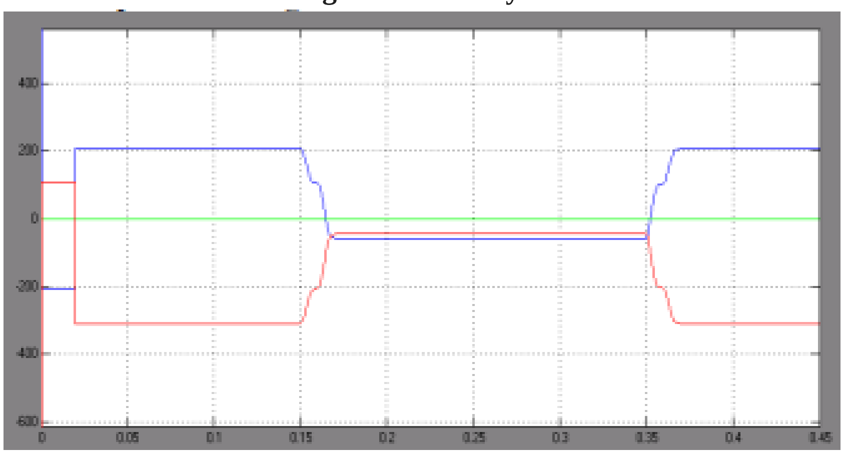

Fig.5.Reactive Grid wave

equipment failures in the underground environment and construction accidents. The solutions within the facility are varied, depending on the financial risk at stake, the susceptibility levels and the power requirements of the effected device. It can also be noticed that the grid reactive power Qgrid reduces during the voltage sag while Qdvr increases to compensate for the reactive power loss in the system. Similar analysis can also be carried out for voltage sags that occur in one of the phases (A, B, or C) or in two of the phases (AB, BC, or CA); however, three-phase voltage sag case requires the maximum active power support and is presented here.

CONCLUSION

In this paper, the concept of integrating UCAP-based rechargeable energy storage to a power conditioner system to improve the power quality of the distribution grid is presented. With this integration, the DVR portion of the power conditioner will be able to independently compensate voltage sags and swells and the APF portion of the power conditioner will be able to provide active/reactive power support and renewable intermittency smoothing to the distribution grid. UCAP integration through a bidirectional dc–dc converter at the dc-link of the power conditioner is proposed. The control strategy of the series inverter (DVR) is based on in phase compensation and the control strategy of the shunt inverter (APF) is based on id−iqmethod. Designs of major components in the power stage of the bidirectional dc– dc converter are discussed.

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