MODELING OF DYNAMIC VOLTAGE RESTORER WITH U-CAP FOR POWER QUALITY IMPROVEMENT

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ABSTRACT: Now a days, the energy storage technologies operational and maintenance charge is decreasing rapidly. The integration of this technology into the distribution power generation, power quality is being enhanced since these devices gives quick response and high reliability. Dynamic voltage restoration is a process and instrument necessity to maintain, or restore and also compensate functional electric load during voltage sag and swell, harmonics in voltage supply. DVR is the most reliable custom power device that can protect sensitive load and it can be thoroughly solved the power quality problem in distribution power generation. Ultra capacitor is a specially designate capacitor which have low-energy density and high- power density, quick charge/discharge rates that area unit all ideal characteristic for meeting high voltage low energy events like grid intermittencies sag/swells. It combined the properties of capacitors and batteries into one device. UCAPs are electronic devices which are able of holding huge amount of electrical intrust quantity. It is also called as Ultra Capacitor (UCAP).

KEYWORDS: DC-DC converters, dynamic voltage restorer (DVR), Ultra capacitor, sag/swell, harmonics.

I.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 aback to back inverter topology was first introduced in and the topology was named as unified power quality conditioner (UPQC). The design goal of the traditional UPQC was limited in this project, 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. This is a serious problem in power system which should be solved before supplying the power. There are different types of remedies available to improve power quality of the power system. Energy storage integration with DERs is a potential solution, which will increase the reliability of the DERs by reducing the intermittencies and alsoaid in tackling some of the power quality problems on the distribution grid. 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. Ultra 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. Ultra 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 objectiveoptimization 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 systems 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. Sag/swell compensation needs active power support from the energy storage in the milliseconds to 1 min duration.

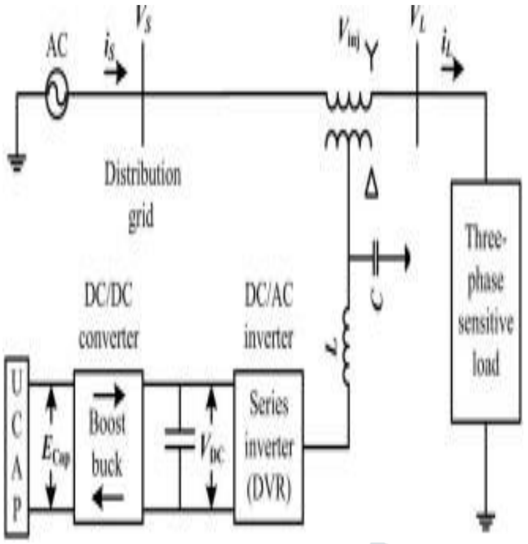

Fig 1.1 Single Line Diagram of DVR with UCAP energy storage system.

In this project, efforts have been made to implement a UCAP based energy storage integration through a power conditioner into the distribution grid is proposed and it is verified from the MATLAB Simulation tool that quality of power which is supplied from source to load can be improved significantly, the following application areas are addressed.

1) Integration of the UCAP with power conditioner system gives the system active power.
2) Active power capability is necessary for independently compensating voltage sags/swells and to provide active/reactive power support and intermittency smoothing to the grid.
3) Experimental validation of the UCAP, DC to DC converter, inverter their interface, and control.
4) Development of inverter and DC to DC converter controls to provide sag/swell compensation and active/reactive support to the distribution grid.
5) Both Hardware integration and performance validation of the integrated UCAP PC system.

II. MODEL DESCRIPTION

A. Bidirectional dc-dc converter

A UCAP cannot be instantly connected to the dc-link of the inverter similar a battery, as the voltage profile of the UCAP varies since its discharge energy. Therefore there's a required to integrate the UCAP voltage decreases whereas discharging and will increases whereas charging. The design of the bidirectional dc-dc converter and its controller area unit show-n in fig.1, whenever the input consist of 1 UCAPs connected in series and the output consist of a nominal load of 213.5 Ω to prevent operation of no-load, and therefore output is connected to dc-link of the electrical converter. The number of active power support required by the grid throughout the voltage sag event depend on the depth and length of the voltage sag, and dc-ac converter should to be capableto consist up this power throughout the discharge mode. The series voltage controller is connected series with the protected load, typically the association is formed via transformer, but configuration with direct connection via power electronics exist. The resulting voltage at the load busequals the complete sum of the grid voltage and the insert voltage which is come from the DVR. The converter produce the reactive power need whereas the reactive power taken from the energy storage. The energy storage is entirely other appearance on the requirements of compensating. DVR will compensate voltage at each transmission and distribution sides, typically a DVR is put in on acritical load feeder. During the normal operating stateDVR works during a low loss standby form throughout this provision the DVR is claimed to be steady state. Once a disturbance occur and supplyvoltage depart from par value, DVR supplies voltage for compensating of sag and swell is claimed to be transient state.

B. Dynamic Voltage Restorer (DVR)

DVR is the most powerful and efficient custom power device. The reason behind this is its lowerexpense, smaller size and its fast response towardsthe disturbances. The main function of DVR is to inject the desired voltage measure in series with the help of an injection transformer whenever voltagesag is detected. DVR is a device which is used to sustain, restore an operational electric load when sag,swell and other disturbance is occurs in voltage supply. This process uses critical device such as an automatic transfer switch and IGBT module in order to work.

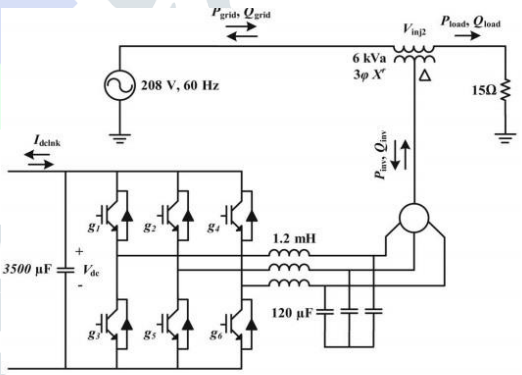

Fig 2.1.Model of 3-phase series inverter(DVR) and its controller

C. Buck Boost Converter

Switched mode supplies can be used for several functions together with dc-dc converters. Often, though a dc supply, such as a battery is also obtainable, its obtainable voltage is not consistent for the system being supplied. For instance the motor used in driving electric vehicles require much higher voltages, with region of 500V, than might be supplied by a battery alone. Although banks of batteries were used, the additional weight and area obsessed would be too great to be sensible. The release to the current downside is to use fewer batteries, large or small, is that their output voltage varies because the obtainable charge is used up. By using boost converter if this low output level booted- up to helpful level again, the battery life is to be increase. It is different to buck converter. That meansoutput voltage is same or greater than input voltage. However it is important to remember that, as power (P) =voltage (V) × current (I), if the output voltage is raised the accessible output current must decrease.

III. PROBLEM STATEMENT

Power quality is the ability to use the energy delivered in the desire manner and to give sufficiently high grade electrical services to the customer. Synchronization of the voltage frequency section permits electrical system to perform their intended manner while not important loss of performance or life. The word is used to explain electric power that drives an electrical load and theload's ability to perform properly. Without the proper power, an electrical device may malfunction. Fail untimely or not operate, which effects the distribution system. There are the some power quality problem defines

A. Voltage Sag

A decrease of the normal voltage level with ranging from 10-90% at any instant of period and for duration of 0.5 cycle to 1 min. Longer duration of low voltage called a 'sustained sag'.

B. Voltage Swell

Voltage swell is defined as temporary increase of the voltage, at the power frequency, external normal tolerances. Or it happens when a heavy load turns off in a power system, with duration of more then one cycle and typically less than a few seconds.

C. Harmonics

A harmonic frequency is a multiple of the fundamental frequency and this frequency of the ac electric power distribution system is 50 Hz. A harmonic frequency is any sinusoidal frequency, Harmonic frequencies can be even or odd multiples of the sinusoidal fundamental frequency

IV. MODELING &SIMULATION RESULTS

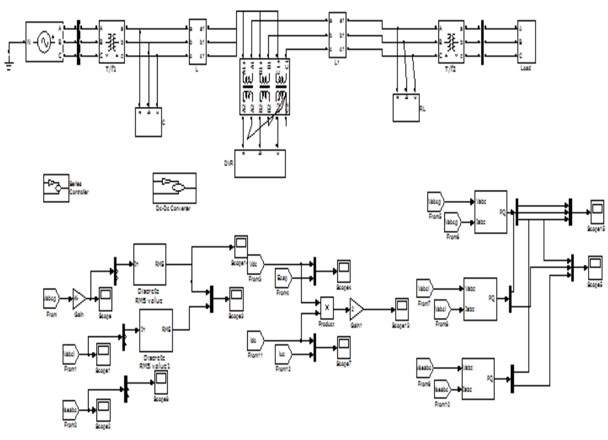

Fig 4.1 Simulink Model of Proposed system

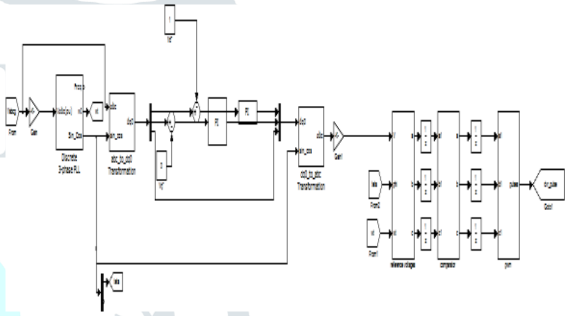

Fig 4.2 Control Circuit Diagram of Proposed System

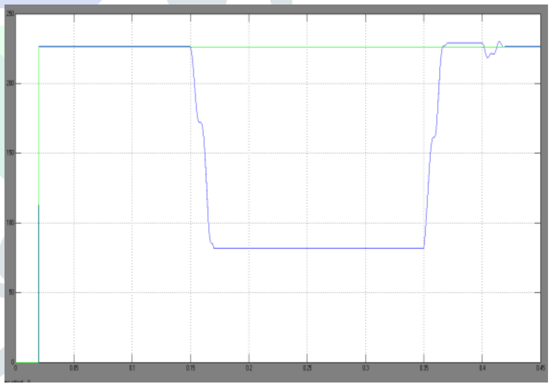

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Fig 4.3 Source and load RMS voltages Vsrms and Vsrms during sag and harmonics

It can be observed from Fig 4.3 that during voltage sag and harmonics injection, the source voltage Vsrms is reduced to 0.5 p.u. while the load voltage VLrms is maintained constant at around 0.9 p.u. due to voltages injected in phase by the series inverter.

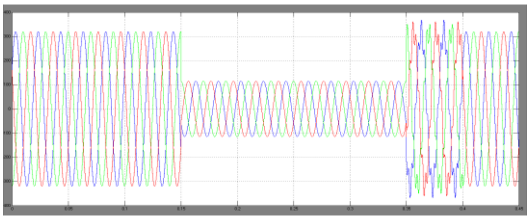

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Fig 4.4 Source voltage during sag and harmonics

The Fig.4.4 shows the source voltage waveforms during voltage sag and harmonics injection, observed from the plots of line to line source voltages [Vsbc, Vsbc, Vsca].

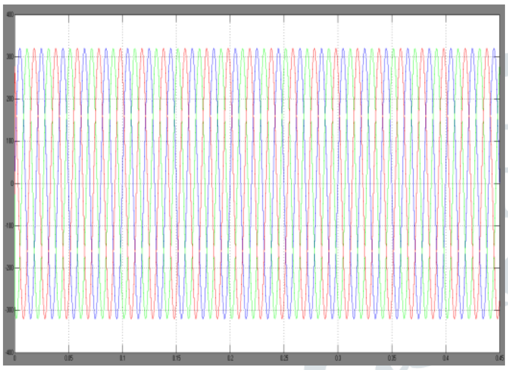

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Fig 4.5 load voltage during sag and harmonics

It can be observed from Fig. 4.5 that during voltage sag and harmonics injection, observed from the plots of the line to line load voltages [VLab, VLbc, VLca].

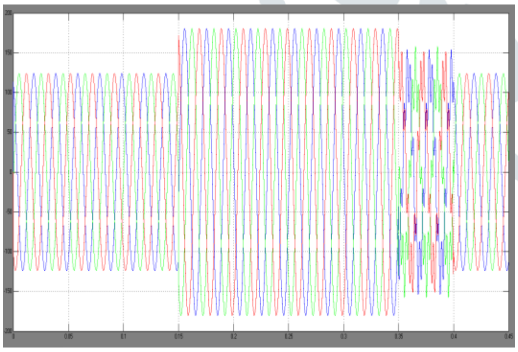

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Fig 4.6 Injected voltage during sag and harmonics

From Fig.4.6 it is verified that during voltage sag and harmonics injection the line to neutral injected voltages of the series inverter [Vinj2a, Vinj2b, Vinj2c] are balancing the loads without any Power quality problem.

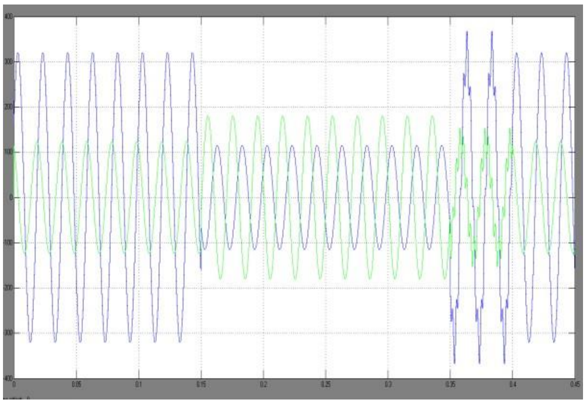

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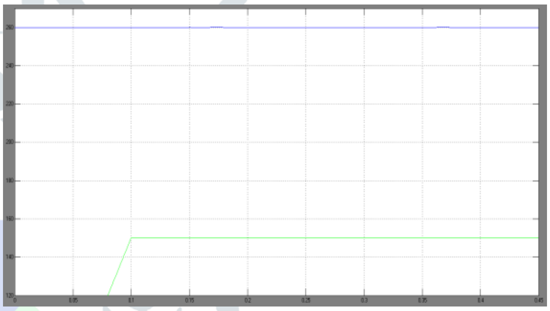
Fig 4.7 Vinj2a and Vsab2a waveforms during sag and harmonics.

It can be observed from Fig. 4.7 that Vinj2a lags Vsab by 30◦, which indicates that it is in phase with the line neutral source voltage Vsa.



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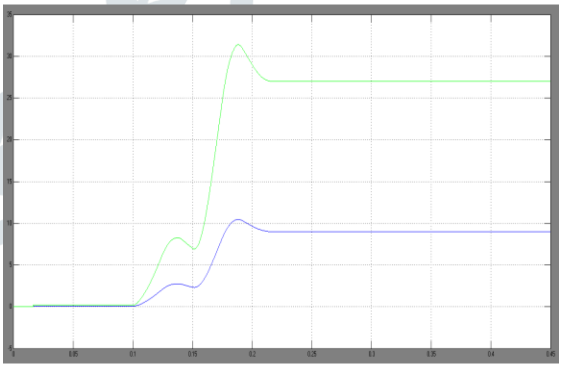

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Fig 4.8 Currents and voltages of DC to DC converter.

In Fig 4.8, plots of the bidirectional DC/DC converter are presented and it can be observed that the DC link voltage Vfdc is regulated at 260 V, the average DC link current Idclnkav and the average UCAP current Iucav increase to provide the active power required by the load during the sag. Although the UCAP is discharging, the change in the UCAP voltage Ecap is not visible in this case due to the short duration of the simulation, which is due to limitations in MATLAB software.

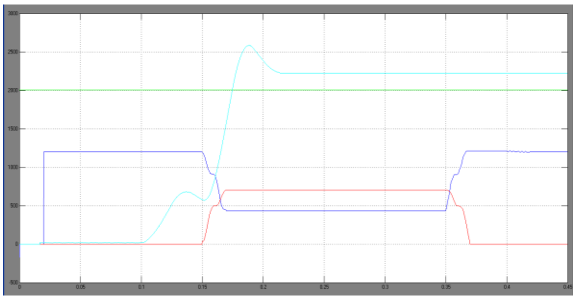

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Fig 4.9 Active power of grid, load, and inverter during voltage sag and harmonics

From the various active power plots shown in Fig. 4.9 where the power supplied to the load Pload remains constant even during the voltage sag when the grid power Pgrid is decreasing. In most cases, the identified applications would require the power converters to be connected in series or shunt, depending on the operating scenarios under consideration. In addition, they need to be programmed with voltage, current, and/or power regulation schemes, so that they can smoothly compensate for harmonics, reactive power flow, unbalance, and voltage variations. For evenmore stringent regulation of supply quality, both shunt and series converter are added with one of them tasked to perform voltage regulation, while the other performs current regulation. Almost always, these two converters are connected in a back- to-back configuration. A much larger DC-link capacitance and voltage need to be maintained, in order to produce the same ac voltage amplitudes as for the back to back converter. Therefore, it can be concluded from the plots that the active power deficit between the grid and the load during the voltage sag event is being met by the integrated UCAP DVR system through the bidirectionalDC to DC converter and the inverter. Similar analysis can also be extended for voltage sags, which occur in one of the phases (a, b, or c) or in two of the phases (ab,bc, or ca).

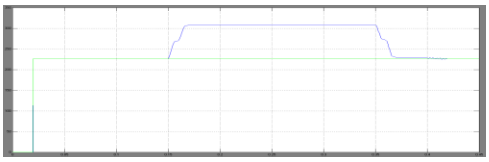

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Fig 4.10 Source and load RMS voltages Vsrms and Vsrms during swell and harmonics

Fig.4.10 shows the RMS values of Source and Load Voltages during voltage swell, the source voltage Vsrms increases to 1.2 p.u., whereas the load voltage VLrms is maintained constant at around 1 p.u. due to voltages injected in phase by the series inverter.

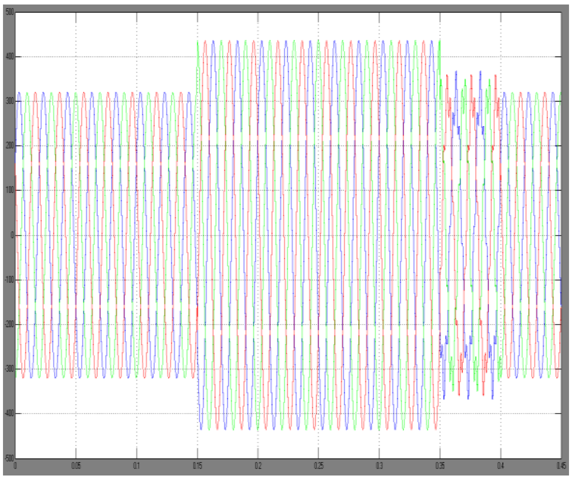

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Fig 4.11 Source voltage during swell and harmonics

From the Fig.4.11 it is concluded that during voltage swell and harmonics injection, the source voltage is increased suddenly for a small duration of time and is observed from the plots of the line to line source voltages [Vsbc, Vsbc, Vsca].

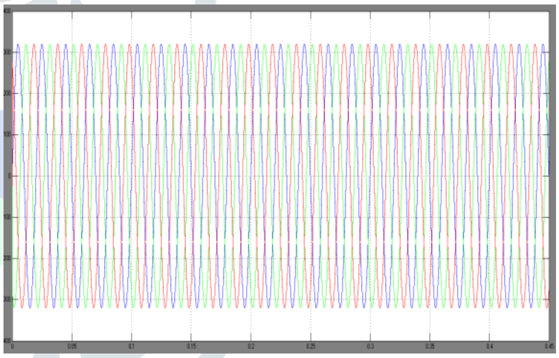

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Fig.4.12 load voltage during swell and harmonics

From the above Fig.4.12 the load voltages during voltage sag and harmonics injection, are observed from the plots of the line to line load voltages [VLab, VLbc, VLca].

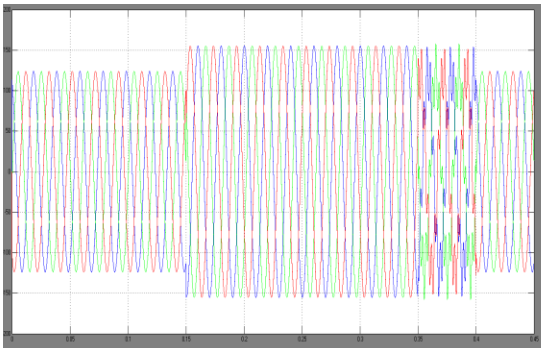

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Fig.4.13 Injected voltage during swell and harmonics

It can be observed from Fig.4.13 that during voltage sag and harmonics injection and the line to neutral injected voltages of the series inverter [Vinj2a, Vinj2b, Vinj2c].

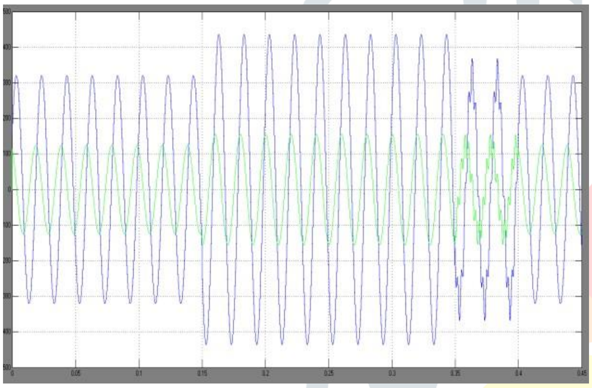

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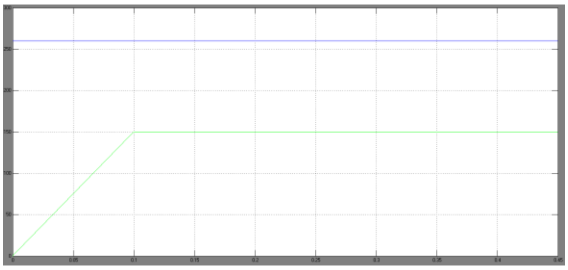
Fig.4.14 Vinj2a and Vsab waveforms during swell and harmonics.

In the above Fig.4.14 it is shown that Vinj2a lags Vsab by 150◦, which indicates that it is 180◦ out of phase with the line to neutral source voltage Vsa as required by the in phase control algorithm such that the dynamic restoration of voltage in the system is achieved .



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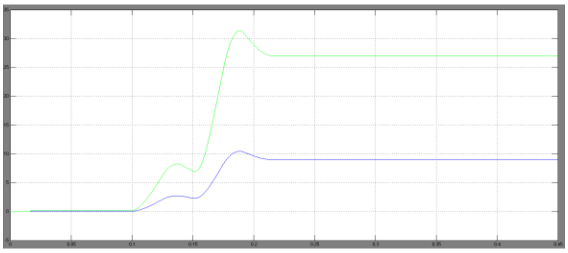

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Fig 4.15 Voltages of DC to DC converter

It can be observed from fig.4.15 that the DC link voltage Vfdc is regulated at 260 V, the average DC link current Idclnkav and the average UCAP current Iucav change direction to absorb the additional active power from the grid into the UCAP during the voltage swell event.

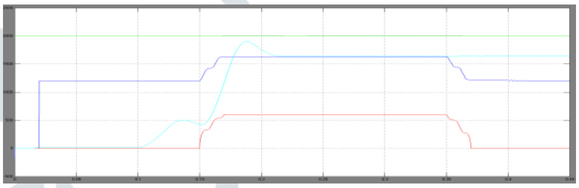

Fig 4.16 Active power of grid, load, and inverter during voltage swell and harmonics

Due to MATLAB limitations, which restrictthe duration of the simulation, the increase in Ecap due to charging of the UCAP during the voltage swell is not visible. This can also be observed from various active power plots where the power supplied to the load Pload remains constant even during the voltage swell when the grid power Pgrid is increasing. It can be observed from the inverter power Pinv and inverter input power Pdc_in plots that the additional active power from the grid is absorbed by the inverter and transmitted to the UCAP. Therefore, it can be concluded from the plots that the additional active power from the grid during thevoltage swell event is being absorbed by the UCAP DVR system through the bidirectional DC to DC converter and the inverter.

V. CONCLUSION

In this project, 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. From 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 simulation of the integrated UCAP PC system which consists of the UCAP, bidirectional DC-DC converter, and the series and shunt inverters is carried out using MATLAB. In addition to Voltage Sag and Voltage Swell, harmonics are also added in the simulink of the integrated system is presented and the ability to provide temporary voltage sag and swell compensation and active/reactive power support and renewable intermittency smoothing to the distribution grid is tested. By using simulation results the concepts introduced in this project are verified. **FUTURE SCOPE**

Dynamic Voltage Restorer (DVR) is used in power distribution system to protect sensitive load in voltage disturbances. Voltage sag is one of the most important power quality problems challenging the utility industry. Voltage sags can be compensated by voltage and power injection into the distribution system. The control strategy of the series inverter (DVR) isbased on in phase compensation and the control strategy of the shunt inverter (APF) is based on id, iq method. Designs of major components in the power stage of the bidirectional DC-DC converter are discussed. Average current mode control is used to regulate the output voltage of the DC-DC converter due to its inherently stable characteristic. A higher level integrated controller that takes decisions based on the system parameters provides inputs to the inverters and DC-DC converter controllers to carry out their control actions. Similar UCAP based energy storages can be deployed in the future in a micro grid or a low voltage distribution grid to respond to dynamic changes in the voltage profiles and power profiles on the distribution grid.

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