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A Survey On, Integrated Dynamic Voltage Restorer-Supercapacitor Analysis For Power Quality Improvement

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Abstract*— Grid integration of distribution energy resources (DERs) is increasing quickly. Integration of different type of energy storage technologies like batteries, ultra capacitor, superconducting magnets and flywheels to support intermittent DER, such as solar and wind so as to enhance their reliability is changing into necessary. The most severe power quality problems in electrical system are called as voltage sag and swell. Super capacitor (SCAP) have low energy density, high power density, quick charge/discharge rates that area unit all ideal characteristic for meeting high voltage low-energy events like grid intermittencies sag/swell. In this paper, the SCAP-DVR system can have active power capability and can ready to severally compensate temporary voltage sag and swell while not looking forward to the grid to complete faults on grid like in previous year. SCAP is integrate into dc-link of the DVR through a bidirectional dc-dc converter that helps in providing a stiff dc-link voltage and conjointly helps in compensating temporary voltage sag and swell, that last from 3 s to 1 min. This paper also discuss the overview of power quality improvement by using PWM technique, using cascaded multilevel inverter, DSTATEC-OM, UPFC etc.

Index Term*— DC-DC converter, d-q control, dynamic voltage restorer (DVR), Supercapacitor, sag/swell.

I. INTRODUCTION

Power Quality issues within the current distribution system area unit addressed within the literature [1], due to the hyperbolic use of sensitive and important items such as communication network, method industries and precise manufacturing process. In [1], the authors propose the usage of the DVR with reversible energy storage at the dc-terminal to meet the active power needs of the grid during power injection into the grid, authors also mention voltage disturbances. So as to avoid and minimize the active power injection into the grid, authors also mention an alternate solution that is to compensate for the voltage sag by inserting a lagging voltage.

The DVR can regulate the load voltage from the problem such as sag-swell, harmonics in the load voltages.

Hence, it can protect the critical consumer loads from tripping and consequent losses. The custom power devices area unit developed and put in at consumer point to meet the power quality standards like IEEE [1]. Renewable energy generation is growing quick and ideas like smart grid are trying to change the role of consumer from being a passive consumer to an active contributor who can supply stored excess power in various DERs such as wind, solar, hybrid electric vehicles (HEVs) and plug- in hybrid vehicle (PHEVs) back to the distribution grid or the micro grid.

Of all the energy storage technologies, SCAPs have low energy density, high power density and fast charge/discharge characteristics. They even have additional charge/discharge cycles and higher terminal voltage per module when put next to batteries, of these characteristic make SCAPs ideal choice for providing support to events on the distribution grid that require high power for brief spans of your time. SCAPs have historically been restricted to regener- ative braking and alternative energy smoothing applications.

The major contribution of this treatise is in integration SCAP for a broader range of application like active/reactive power support, , renewable intermittence smoothing, voltage sag/swell compensation and power quality conditioning to the distribution grid. Renewable intermittence smoothing is associate degree application which needs to bidirectional transfer of power from the grid to the SCAPs and vice-versa by charging and discharging the SCAP. This application needs high active power support within the 10s-3min continuance which may be achieved by integrating SCAPs through a shunt active power support in the 3s-1min time scale which can be provided integrating SCAP into the grid through series dynamic voltage restorer (DVR). All the on top of functionali- ties can also be provided by integrating the SCAP into an influence conditioner topology.

Energy storage integration to a DVR into the distribu- tion grid is planned and the following application areas are addressed.

- Integration of the SCAP with DVR system offers power capability to the system, that is important ind- ependently compensating voltage sag and swell.
- Experimental validation of SCAP, dc-dc converter and inverter their interface and control.
- Development of inverter and dc-dc converter controls to supply sag and swell compensation to the distribution grid.
- Hardware integration and performance validation of the integrated DVR-SCAPs system.

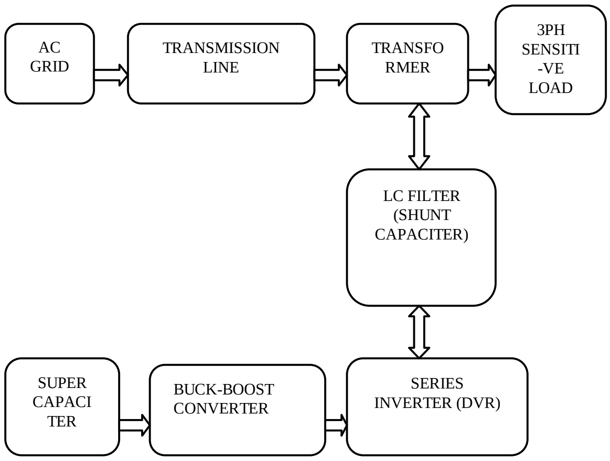

Fig.1. One-line diagram of DVR with SCAP energy storage.

II. MODULE DESCRIPTION

1. Bidirectional dc-dc converter

A SCAP cannot be directly connected to the dc-link of the inverter like a battery, as the voltage profile of the SCAP varies because its discharge energy. Therefore there's a desire to integrate the SCAP voltage decreases whereas discharging and will increases whereas charging. The model of the bidirectional dc-dc converter and its controller area unit show-n in fig.1, whenever the input consist of 3 SCAPs 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 needed by the grid throughout the voltage sag event depend on the depth and length of the voltage sag, and dc-ac converter ought to be able to stand 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 bus bar equals the total sum of the grid voltage and the injected voltage from the DVR. The converter generates the reactive power required whereas the reactive power taken from the energy storage. The energy storage is totally different looking on the requirements of compensating. DVR will compensate voltage at each transmission and distribution sides, typically a DVR is put in on a critical load feeder. During the normal operating condition DVR operates during a low loss standby mode throughout this condition the DVR is claimed to be steady state. Once a disturbance happens and supply voltage deviates from par value, DVR supplies voltage for compensating of sag and swell is claimed to be transient state.

2. 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 accessible, its accessible voltage is not suitable 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 solution to the current downside is to use fewer batteries, large or small, is that their output voltage varies because the accessible charge is used up, and at some purpose the battery voltage become too low to power the circuit being supplied. However if this low output level may be boosted back up to a helpful level again, using a boost converter, the life of the battery can be extended. The dc input to a boost converter can be from several sources additionally batteries, such as rectified ac from the mains supply, or dc from solar panels, fuel cells, dynamos and dc generators. The boost converter is different to the buck converter in that it's output voltage is equal to, or greater than its 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.

3. Supercapacitor

Supercapacitor, also referred to as ultracapacitor is an electrical element capable of holding many times additional electrical charge amount than a standard capacitor. This characteristic makes ultracapacitor helpful in devices that need comparatively current and low-voltage electrochemical battery. These devices, unlike their electromechanical counterparts, store information about home and business electric-al power and energy consumption, and contain no moving parts. Within the event of a power failure, an ultracapacitor permits the meter to send a final stat-us communication to the utility company, preventing data loss and the confusion that might result. The ultracapacitor charges up with the help of a miniature direct-current (dc) generator that the user can manually operate for a couple of minutes by turning a small crank. Once the ultracapacitor has acquired a full charge, the device can function for quite awhile before it needs a recharge.

III. LITERATURE REVIEW

The important task of the various devices is to mitigate the voltage sags/swells and harmonic, flicker etc and enhance the power quality. This section provides a detailed discussion about several power quality improvement techniques. The following section discusses the various works of several authors. Deepak S. et al [1] has proposed power quality improvement method. This experiment and result is agree well with each other thereby verifying the concepts introduced in this paper. Similar UCAP based energy storages can be deployed in the future on the distribution grid to respond to dynamic changes in the voltage profiles of the grid and prevent sensitive loads from voltage disturbances.

M. Jayapriya et al [2] has proposed that the UCAP in integration through a bidirectional dc–dc converter at the dc-link of the DVR is proposed. The power stage and control strategy of the series inverter, which acts as the DVR, are discussed. The control strategy is simple and is based on injecting voltages in-phase with the system voltage and is easier to implement when the DVR system has the ability to provide active power.

K.C. Anandhan et al [3] has presented the concept of integrating UCAP-based rechargeable energy storage to a power conditioner system to improve the power quality of the distribution grid. 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.

U. Vidhu et al [4] has describe once a voltage disturbance occurs, with the aid of dqo transformation based control scheme, the inverter output can be steered in phase with the incoming ac source while the load is maintained constant. As for the filtering scheme of the proposed method, output of inverter is installed with capacitors and inductors. The simulation shows that the DVR performance is satisfactory in mitigating voltage sags/swells.

S. Rajaseker et al [5] is investigates mitigation of current harmonics using different configuration of cascaded multilevel inverter based shunt hybrid active power filter (SHAPF) and to improve power quality of the system.

Rosli O. et al [6] shows the configuration of the proposed DVR design using MATLAB/SIMULINK, where the outputs of a three-phase half-bridge inverter are connected to the utility supply via wye-open connected series transformer. From simulation results also show that the DVR compensates the sags/swells quickly and provides excellent voltage regulation.

Priyanka K. et al [7] has presents that in her paper, modeling, analysis and simulation of a Dynamic Voltage Restorer (DVR) using MATLAB. The efficiency of the DVR depends on the performance of the efficiency control technique involved in switching the inverters. In this model a PI controller and Discrete PWM pulse generator is used.

Pychandathil J. et al [8] has describe the different voltage injecting schemes for dynamic voltage restorers (DVRs) are analyzed with particular focus on a new method used to minimize the rating of the voltage source converter (VSC) used in DVR. A new control technique is proposed to control the capacitor-supported DVR.

Ankit panday et al [9] has presented that, the study and analysis of DVR and power quality problems, voltage sag & swells with its application at Low Voltage and Medium Voltage level. DVR is always connected in series with the distribution feeder. The basic principle of a DVR is simple, by supplying a voltage of desired magnitude and frequency, the DVR restores the load voltage to a desired pre-sag voltage quantity even when source voltage is not balanced. Implementation of DVR has been proposed at both low voltage level as well as medium voltage level thus giving an opportunity to protect high power sensitive loads from voltage deflections.

Anu R. et al [10] has proposed a control unit for the STATECOM based on instantaneous reactive power theory (IRPT) control algorithm by which reactive power compensation and power factor correction is done and also real power support is provided by renewable energy source through STATECOM.

IV. PROBLEM STATEMENT

Power quality determines the fitness of electric power to consumer devices. Synchronization of the voltage frequency section permits electrical system to perform their intended manner while not import-ant loss of performance or life. The term is used to describe electric power that drives an electrical load and the load’s ability to perform properly. Without the proper power, an electrical device may malfunction. Fail untimely or not operate at all. There are many ways in which electric power can be of poor quality and many more causes of such poor quality power.

- Voltage sag
  Voltage sag can occur at any instant of time, with amplitudes ranging from 10 - 90% and a duration lasting for half a cycle to one minute.

- Voltage swell
  Voltage swell is defined as an increase in rms voltage or current at the power frequency for duration from 0.5 cycle to 1 min.

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

V. METHDOLOGY

In previous papers, we studied the different technique and method of power quality improvement by using the various power electronic and other energy storage devices. In this paper some methods are discuss.

A. UCAP-Integrated DVR system
B. By using cascade multilevel inverter
C. DVR with a battery energy storage device
D. DVR and its application at MV and LV level
E. Using STATECOM with different control algorithms

A. UCAP-Integrated DVR system

The UCAP-DVR system is able to compensate temporary sags/swells or interruptions on the distribution grid, which last from 3 s to1 min and require active power support. This kind of integration will be necessary to improve the active power capability of the DVR [1].

B. By using cascade multilevel inverter

To mitigate harmonic distortion, cascaded multilevel inverter based shunt hybrid active power filter is proposed and after compensation the source current harmonic distortion is reduced to 2.93%. The simulation analysis is carried out using SIMPOWERSYSTEMS block set of MATLAB/SIMULINK to determine which of the inverter topology based shunt hybrid active power filter strategy perform better on compensating source current harmonic distortion [5].

C. DVR with a battery energy storage device

A new control technique is proposed to control the capacitor-supported DVR. The control of a DVR is demonstrated with a reduced-rating VSC. The reference load voltage is estimated using the unit vectors. The synchronous reference frame theory is used for the conversion of voltages from rotating vectors to the stationary frame. The compensation of the voltage sag, swell, and harmonics is demonstrated using a reduced-rating DVR [8].

D. DVR and its application at MV and LV level

In this method a DVR can be used at both Low level voltage as well as Medium level voltage. On this basis, a DVR can be of two types. The first DVR is a Low voltage DVR (LV-DVR) rated for 10 kVA for insertion in 400 volt low voltage grid and the second DVR is a Medium voltage DVR (MV-DVR) rated for 200 kVA for insertion in 10 kV medium voltage distribution system [9].

E. Using STATECOM with different control algorithms

In this method a STATECOM unit is developed for interfacing renewable energy source to the grid with improved power quality. Instantaneous reactive power theory and synchronous reference frame algorithm was developed for generating control pulses for the STATECOM unit. The STATECOM unit provide power factor correction, real and reactive power compensation and voltage regulation. The STATECOM unit with SRF algorithm provide better performance with input power factor of 0.9549 and source voltage and current THD of 0.5722, 0.544 respectively [10].

V. CONCLUSION

This paper presented on innovative technology management by critical analyzing about power quality problem, issues and their effect in life and the corrective measure and solution by using DVR and other battery storage devices. This paper mentioned about various techniques like UCAP-In Integrated DVR system, *DVR* with a battery energy storage device, DVR with a battery energy storage device, Using STATECOM with different control algorithms, DVR and its application at MV and LV level method available for power quality important.

This previous paper has attempted to give an overview of how power quality improvement is done and general study of how a DVR can be such useful for the sensitive loads. In this survey, we summarized the existing power quality technique and concluded some results. An integration of DVR-SCAPs based energy storages can be deployed in the future on the distribution grid to respond to dynamic changes in the voltage profiles of the grid and prevent sensitive loads from voltage disturbances.

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