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Integrated UPQC Based Design and Performance Analysis of Three-Phase Solar PV

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Abstract –

This project mainly deals with the improvement of the power quality of the output of the three phase single stage Solar Photo Voltaic plant by coordinating it with the Unified Power Quality Conditioner (UPQC). The UPQC contains shunt and series voltage compensators connected in back to back connection. These are used to extract the power from the PV array as well as compensating the voltage and load current harmonics. The compensator injects the voltage in-phase/out of phase with point of common coupling (PCC) voltage during swag and swells conditions to improve the voltage at load side. Thus by combining the Solar PV Array with UPQC we can obtain clean energy with improved power quality.

Due to the increase of electricity load demand in upcoming future, the power generation must also increase as the demand. The excess use of limited traditional resources such as coal, diesel fuels etc., causes global warming and air pollution which is leading us to use to renewable energy resources. Available renewable energy resources may include solar, wind, tidal as the source for energy production. These are mainly used in small quantities as Distribution Generators (DG) at different locations in a bus system and many more. As the generation of these energy sources is produce less when connected to grid, so we call them as micro-grids. These micro grids generally use these DGs to distribute power to various loads, and involve some power electronic elements to control the energy generation. Also it induces energy into the load system but also create a major problem of harmonic distortions and voltage sags.

Key Words: Power Quality, DSTATCOM, DVR, UPQC, Solar PV, MPPT, Power Conditioner,PQ issues,Flelxible AC transmission System(FACTS) Devices, Unified Power Quality Conditioning System (UPQC) ,Multiconverter UPQC(MC-UPQC), Voltage Source Converter(VSC) and MATLAB.

1. 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. One area of study for the connection of a micro grid to the distribution grid is the impact of power quality (PQ) problems on the overall power system performance. These power quality problems creates voltage and frequency deviations in the micro grid voltage and also harmonics in the present grid voltage and load currents., several power conditioning equipments such as active filters, uninterruptible power supplies, dynamic voltage restorers and unified PQ conditioners are usually employed by consumers to protect their loads and systems against PQ disturbances in the distribution network. However, these devices are usually installed at the consumer sides and the PQ problems that they are capable to handle are usually limited. This paper proposes a flexible ac distribution system device for the micro grid that is realized using a combination of series and shunt voltage source inverters (VSIs). The proposed device is installed at the point of common coupling (PCC) of the distribution grid that the micro grid another electrical loads are connected to. The proposed methods for the dc-link voltage of the flexible ac distribution process device consists of a photovoltaic (PV) array and a battery to store the excess power generated by the PV array and to provide power during sunless hours and distribution. The devices equipped with the capability to improve the PQ and reliability of the micro grid. During the proposed operation of the micro grid, the system can provide real and reactive power to the micro grid distribution. The proposed controller system is based on a newly tested and developed model predictive control (MPC) algorithm to track down the periodic reference signals for fast sampling linear time-invariant (LTI) systems that are subject to input constraints of the system. This newly developed control methodology controls the input signals of the VSIs and overcomes the control problem into proper steady-state and generates sub problems which are optimized separately. In this way, the computational times can be greatly reduced

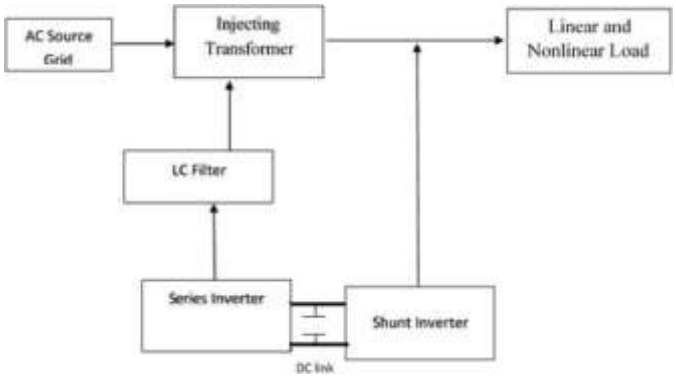

Fig. 1. System Configuration PV-UPQC

In what follows, this paper provides a comprehensive solution for the operation of the flexible ac distribution system device

for a micro grid based on a multi-input–multi-output (MIMO) state space model. The device wills accomplish the following tasks simultaneously:

1) Compensating for harmonics in the grid voltage and load currents;

2) Real and reactive power control for load sharing during peak periods and power factor correction at the grid side;

3) Maintaining PQ despites light voltage and frequency variations in the grid voltage and

4) Momentarily dispatching real and reactive power to the micro grid when it becomes is landed.

2. Literature Survey

With the advancement in semiconductor technology globally, there is an increased penetration of power electronic loads. These loads may as computer power supplies, adjustable speed drives, switched mode power supplies etc. due to this they have very good efficiency life, and also they draw nonlinear currents. These nonlinear currents cause voltage distortion at point of common coupling particularly in distribution systems. There is also increasing usage on clean energy generation through installation of rooftop PV systems in small apartments as well as in commercial buildings now a day's [1], [2]. However, due to the intermittent nature of the PV energy sources, an increased penetration of such systems, particularly in weak distribution systems leads to voltage quality problems like voltage sags and swells, which eventually instability in the grid [3]–[7]. These voltage quality problems also lead to frequent false tripping of power electronic systems, malfunctioning and false triggering of electronic systems and increased heating of capacitor banks etc [8]–[10]. Power quality issues at both load side and grid side are major problems faced by modern distribution systems. Due to the demand for clean energy as well as stringent power quality requirement of sophisticated electronic loads, there is need for multifunctional systems which can integrate clean energy generation along with power quality improvement. A three phase multi-functional solar energy conversion system, which compensates for load side power quality issues, has been proposed in given references [11], [12]. A single phase solar pv inverter along with active power filtering capability has been proposed in [13], [14]. Major research work has been done in integrating clean energy generation along with shunt active filtering. Though shunt active filtering has capability for both load voltage regulation, it comes at the cause of injecting reactive power. Thus in the given system shunt active filtering cannot regulate PCC voltage as well as they maintain grid current unity power factor at same time in the distribution. Recently, due to the stringent voltage quality requirements for sophisticated electronics loads, the use of series active filters has been proposed for use in small apartments and commercial buildings [15], [16]. A solar photovoltaic system integrated along with dynamic voltage restorer has been proposed in [17]. Compared to shunt and series active power filters, a unified power quality conditioner (UPQC), which has both series and shunt compensators can perform both load voltage regulation and maintain grid current sinusoidal at unity power factor at same time. Integrating PV array along with UPQC, gives the dual benefits of clean energy generation along with universal active. The integration of PV array with UPQC has been reported in [18]–[20]. Compared to conventional grid connected inverters, the solar PV integrated UPQC has numerous benefits such as improving power quality of the grid, protecting critical loads from grid side disturbances apart from increasing the fault ride through capability of converter during transients. With the increased emphasis on distributed generation and micro grids, there is a renewed interest in UPQC systems [21], [22].

3. Body of Paper

The design procedure for PV-UPQC begins switches the proper sizing of PV array, DC link capacitor, DC-Link voltage level etc. In the system the shunt compensator is sized such that it handles the peak power output from PV array apart from compensating for the load current reactive power and current harmonics in the system. As the PV array is directly integrated to the DC-link of UPQC system, the PV array is sized such that the MPP voltage is same as desired DC- link voltage generation. The outcome rating is such that, under nominal generation, the PV array supplies to the load active power and also feeds power into the grid generation. The other fully tested and designed components are the interfacing inductors of series and shunt compensators and series injection transformer of the series compensator system.The configuration of the micro grid considered in this paper for implementation of the flexible ac distribution system device .The flexible ac distribution system device is operated in two modes:

1) PQ compensation and

2) Emergency operation.

During grid connected operation, the micro grid is connected to the distribution grid at the PCC. In this mode, the two DG units are controlled to provide local power and voltage support for loads 1–3 and hence reduce the burden of generation and delivery of power directly from the utility grid. The flexible ac distribution system device functions toCompensate for any harmonics in the currents drawn by the nonlinear loads in the micro grid so that the harmonics will not propagate to the rest of the electrical loads that are connected to the PCC. Because of the intensity of light, light irradiance, change of angle of incident light on the solar panel, output current and voltage may vary. • So we are trying to smooth the fluctuations of these voltage and current by integrating the Solar PV Array with the Unified Power Quality Conditioner (UPQC).

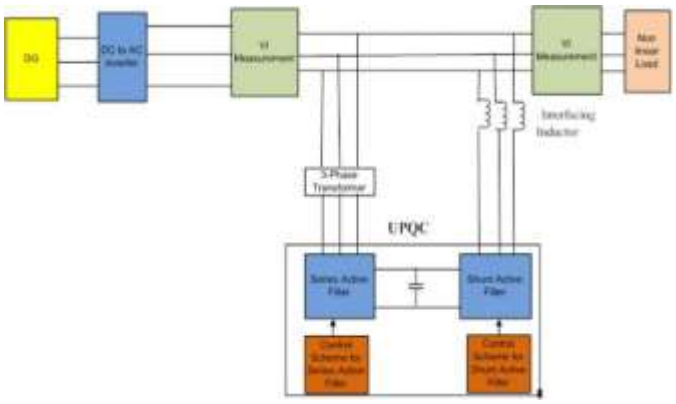

Fig-2: Basic block diagram of DG with UPQC

The device also functions to compensate for harmonics in the grid voltage that are caused by other nonlinear loads that are connected at the PCC. The energization and distribution of large loads and rapid uses and changes in the load demand may also result in voltage and frequency variations in the grid voltage distribution. Therefore, the proposed or system is also equipped with the capability to handle such voltage and frequency variations in the given system. When a fault occurs on the upstream network of the grid, the CBs operate to disconnect the micro grid from the grid. The DG units are now the only available power sources left to distribute to the loads.

4. CONCLUSIONS

It is observed that PV-UPQC mitigates the harmonics caused by nonlinear load and maintains the THD of grid current under limits of IEEE-519 standard.

Voltage sags and current harmonics are the most important power quality problems in commercial and industrial utility's customers. These power quality problems can cause tripping of sensitive electronic equipment, abnormal operations of facilities and tremendous economic losses. Custom Power devices have now been of interest for more than a decade that are able to improve the reliability and the quality of power delivered to electric power customers. Unified Power Quality Conditioner consisting of two voltage source inverters with a common DC link is a Custom Power device and can simultaneously perform the tasks of Active Power Filter and Dynamic Voltage Restorer

The system is found to be stable under variation of irradiation, voltage sags/swell and load unbalance. The performance of d-q control particularly in load unbalanced condition has been improved through the use of moving average filter. • It can be seen that PV-UPQC is a good solution for modern distribution system by integrating distributed generation with power quality improvement.

Thus we can generate clean energy with improved power quality by integrating the Solar PV with UPQC.

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