DISTRIBUTED GENERATION HYBRID SYSTEM POWER QUALITY BY USING DSTATCOM

MEKALA KIRAN 1*, N. SATHISH 2

1. M.Tech(PE) Student. 2. Assistant Professor
Dept of EEE, SRI SAI EDUCATIONAL SOCIETY'S GROUP OF INSTITUTIONS,
JNTUH, NALGONDA DISTRICT, TELANGANA, INDIA

ABSTRACT:

This project presents detailed studies involving sizing, stability analysis, and power flow through the series and parallel power converters in a multifunctional three-phase distributed generation (DG) system composed of a single-stage photovoltaic (PV) system and the wind energy. The most important operational requirement in power network at both transmission and distribution levels. Whenever there is a penetration of photovoltaic cell power to the low voltage distributed grid. For the photo voltaic system MPPT technique is used. DFIG is used in the wind energy. Power quality is the major problem that occurs between grid to end user transmission lines. In this paper one of the FACTS controller devices D-STATCOM is used to improve the voltage regulation thereby the power system stability. DSTATCOM is the one of the power quality compensating device which will rectifies the power quality problems such as voltage sag and swell which occurs in high voltage power transmission lines. The use of distributed energy resources is increasingly being pursued as a supplement and an alternative to large conventional central power stations. In the grid-connected mode, the DG system performs active power-line conditioning, while injecting the energy produced by the PV array into the grid. In islanded operation, the system can act as ac grid forming via a parallel inverter, whether there is the presence of an energy storage system. Distribution Static Compensator (DSTATCOM) is proposed for compensation of reactive power and unbalance caused by various loads in distribution system.

Keywords: BESS, Circuit breaker, switch off time period, ESS.

1. INTRODUCTION:

Distributed generation (DG) systems based on renewable energy sources (RES) are currently emerging as an alternative for large and decentralized conventional power plants connected to long power transmission/distribution networks [1], [2]. DG systems based on RES can be added to new electric power systems (EPS) to meet increasing power demands, reduce power transport costs, improve system reliability due to increased demand, and reduce harmful environmental impacts caused by pollutant sources of energy, such as oil, coal, and natural gas.

Given the low environmental impact and abundance, primary RES, such as solar and wind, have been widely used in the scenario involving the proliferation of DG systems [2], [3]. In particular, the power generation by means of photovoltaic (PV) systems connected to the utility grid deserves special attention, since they can involve small-, medium-, and large-scale power generation systems.

PV systems, when connected to the single-phase or three phase EPS, have the purpose of injecting into the grid the energy coming from PV arrays [4]–[17], which can consist of one or more series- or parallel-connected solar panels. Once the PV array generates energy in the form of dc current, an inverter stage is required, i.e., it is necessary to use at least one power converter between the PV array and the grid [4]–[11]. In contrast, when the voltage in the dc bus of the PV array is not high enough to supply the dc bus of the inverter stage, a boost dc–dc converter must be used [12]–[14]. Thus, the PV systems can be classified as single- or double-stage power conversion systems. In the single-stage PV system, maximum power point tracking (MPPT) is necessarily performed by the dc–ac converter [9], [10], while in the double-stage PV system, this task is usually performed by a boost dc–dc converter [14]. Regardless of the PV system topology, the power balance between the PV system and the power grid is performed by the inverter dc-bus voltage control. In other words, the dc-bus voltage controller must increase or decrease the amplitude of the inverter sinusoidal current references to ensure that the power generated by the PV array is equal to the power injected into the grid plus the system losses, so that the power balance is maintained.

The functionalities of PV systems can be highlighted in several applications. This happens because, besides injecting active power into the grid [3]–[13], [18], [19], PV systems can simultaneously perform some type of power-line conditioning and subsequently improve power quality (PQ) indicators, which are related to the following indexes [20]: line utilization factor [power factor (PF) and fundamental PF], harmonic pollution factor, and load unbalance factor.

In [14]–[17], PV systems have acted similarly as parallel active power filters (P-APF), compensating for reactive power, as well as suppressing current harmonics generated by nonlinear loads. In [21]–[24], PV systems have been employed to operate integrated with unified power quality conditioners (UPQC) [25]–[28].

Although the main role of UPQC systems is performing series–parallel compensation, so that they can simultaneously act as series APF, compensating for mains voltages, as well as acting as P-APF, compensating the load currents, in [1] experimental results of the single-stage PV system integrated with UPQC performs only the function of a dynamic voltage restorer. In this case, only the disturbances of the grid voltages are compensated. In [2], a double-stage PV system integrated with the UPQC, named SPV-UPQC-P, has been evaluated only through computer simulations. However, this system only compensates reactive power of the load and unbalances of the grid voltage. Thus, the suppression of grid voltage as well as load current harmonics has not been taken into account. Another application in which the PV system is integrated with the UPQC is presented in [3]. In this application, the system can operate as a grid forming in an acmicrogrid [9], since different types of DG sources (PV, wind, and others), as well as energy storage systems, can be used as grid-forming units in an islanded microgrid [9]. However, transients/disturbances could be observed in the voltages that fed the load when the system was transferred from the grid-connected operation mode to the grid-islanded operation mode. This happens because the parallel converter of the UPQC needs to change its control mode from current source to voltage source. The same effect occurs when the system returns to operate in the grid-connected mode, because the parallel converter must be controlled again as the current source.

2. RELATED STUDY:

Since the parallel converter is voltage controlled, so that balanced and regulated voltages can be provided to the load, there is no need to change its control mode when the system operates as grid forming in an ac microgrid. In other words, the parallel converter is voltage controlled in both grid-connected and grid-islanded modes. On the other hand, the mentioned system can also operate either as grid feeding or grid supporting [19] in an ac microgrid, since the control mode of the parallel converter can also be switched to operate from voltage source to current source.

On the other hand, in [24], studies related to stability analysis, detailed study related to active and apparent power flows and mainly the sizing and protection of the power converters that compose the PV-UPQC system, have not been addressed. Thereby, additional research advances and contributions are presented in this paper, as follows.

1) A complete study involving the power flow through the PV-UPQC system for obtaining the overall understanding of the system working under several operation modes is performed. This study represents an important and useful methodological tool for designing the power converters properly. It is supported by means of an extensive number of sizing curves and allows the designer an effective power converters sizing.

2) A strategy to avoid over power rating of the series and parallel power converters is implemented. This strategy is needed in order to establish the priority of the power flow through the converters, since the PV-UPQC system performs, simultaneously, grid active power injection (energy produced from the PV system), as well as the power-line conditioning.

3) The stability analysis of the PV system is performed. In the context of a UPQC, the study involving the ability of the series and parallel converters to remain stable even in the occurrence of disturbances in both the load currents and grid voltages has never been addressed before in the literature and appears as an important and necessary subject to be discussed. Furthermore, it is checked if the system stability is affected or not by different grid impedance characteristics.

4) The PV-UPQC system is also tested in grid-islanded operation. This operation mode allows exploring new aspects related to the multifunctionality of the PV-UPQC system.

3. PROPOSED SYSTEM:

The DSTATCOM is integrated near to the PCC in a three-phase four wire distribution system as PQ-mode to compensate all current-related issues like eradication of current harmonics, reactive-power exchanging, load-balancing, neutral current elimination and power factor correction, etc. The DSTATCOM is interfaced into three-phase distribution system to drive the balanced non-linear load and sudden interrupted load. It comprises of various elements such as, DC-link capacitor as C_{vdc}, three-phase voltage-source inverter (VSI) as PQ-VSI is designed by IGBT switches, line-interfacing filter R_{Labc} circuit, sensing elements, reference current generator, gate-pulse switching circuitry, etc. The block diagram of proposed DG-integrated DSTATCOM topology at PCC of three-phase 4-wire distribution system is illustrated in Fig.3.1. The significant control strategy provides the optimal switching states to DSTATCOM by sensing the accurate values of load and source parameters by using signal analyzers.

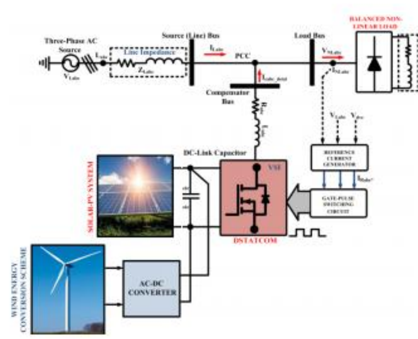

Fig.3.1. Proposed model.

Generally, the DG scheme requires additional source as battery energy storage system (BESS), but it requires additional charge management schemes. Over the BESS, the renewable energy plays a significant role in DG schemes, in that SPV-Wind is the major power producer as COgeneration scheme. The SPV-Wind is the primary source of VSI, commonly which is integrated to DC-link capacitor Cdc by utilizing high-voltage gain DC-DC converter. This boost converter transforms the low-level SPV-Wind voltage into high-level required voltage to drive the VSI of STATCOM and sustains DC-link voltage Vdc as constant. The appearance of DSTATCOM is typically adopted from active-filtering technique working based on in-phase current injection methodology at PCC level of distribution system.

4. SIMULATION RESULTS:

In this section, the proposed strategy developed to avoid the over power rating of the parallel NPC inverter is tested by means of numerical simulation using the MATLAB/Simulink tool. In such tests, it is defined that the parallel converter is sized to process a maximum apparent power *Spc*max = 3 kVA. Fig 8.1 shows the SIMULINK circuit diagram of the PV-UPQC system. Figure 8.2 shows grid voltages (*vs abc*), fig 8.3 indicates grid currents (*is abc*), fig 8.4 shows load voltages (*vL abc*), fig 8.5 shows parallel converter currents (*ipc abc*). fig 8.6 shows load currents (*iL abc*). Fig 8.7 and 8.8 indicates the DC link voltage and pv power.

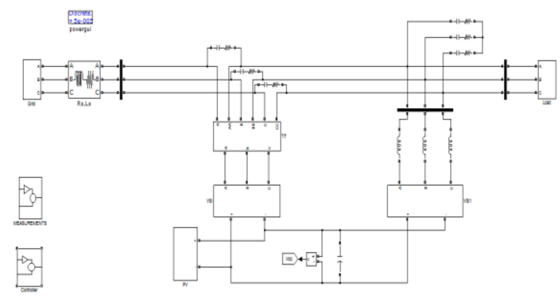

Fig.4.1. Simulation circuit.

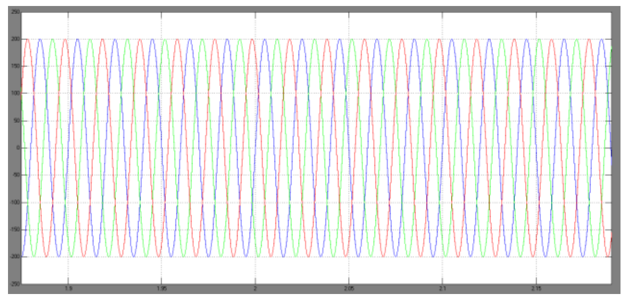

Fig.4.2. Grid voltage

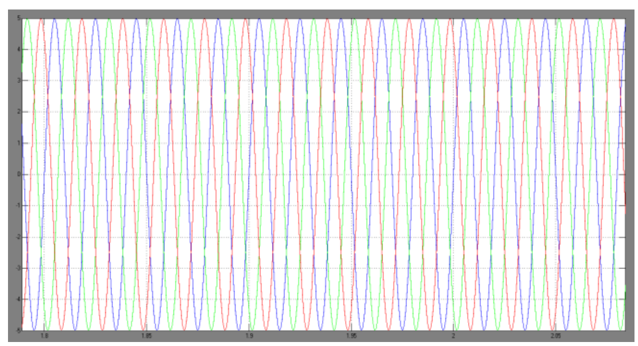

Fig 4.3 Grid current

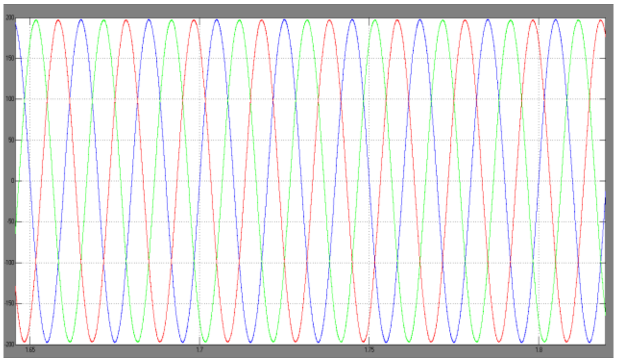

Fig 4.4 Load voltage

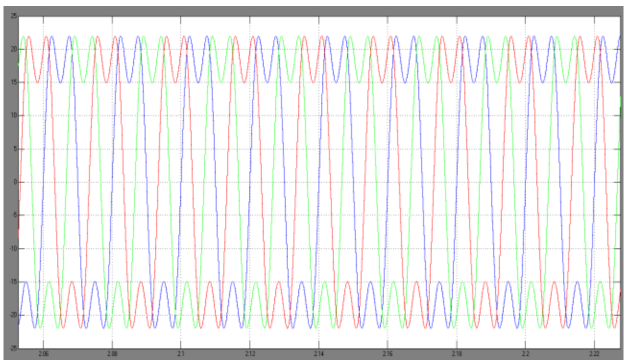

Fig 4.5 Parallel converter currents

5. CONCLUSION:

In this paper PV based UPQC is proposed. The UPQC operates as a bidirectional interface when the DG system is placed between the grid and either generic loads or ac microgrid. In the grid-connected mode, the DG system performs active power-line conditioning, while injecting the energy produced by the PV array into the grid. In islanded operation, the system can act as ac grid forming via a parallel inverter, whether there is the presence of an energy storage system. A complete study involving the power flow through the PV-UPQC is mandatory to achieve the overall understanding of the system operation and designing the power converters properly.

In the extension we present the renewable energy sources based FACTS device (i.e., PV-WIND DSTATCOM) based control scheme for power quality improvement in grid connected system with nonlinear load. The power quality issues and its consequences on the consumer and electric utility are presented. The operation of the control system developed for the STATCOM in MATLAB/SIMULINK for maintaining the power quality is to be simulated. It has a capability to cancel out the harmonic parts of the load current. The PV-WIND connected DSTATCOM device gives the good performance.

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