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PERFORMANCE IMPROVEMENT OF THREE PHASE GRID-TIED PV SYSTEM WITH UPQC

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Abstract: This paper proposes a single stage three-phase four-wire grid-connected photo voltaic (PV) system, operating with a dual compensating strategy. The DC-bus voltage at the dc-link is improved by the PV system. Since the UPQC system is based on a dual compensation strategy. The parallely connected inverter operates as a sinusoidal voltage source, whereas the seriesly connected inverter operates as a sinusoidal current source. This project proposes, an improvement in the real power and reactive power flow through the transmission line with UPQC using PID controller when compared to the system without UPQC.

Index Terms: DG-Distributed Generation, NPC- Neutral Point Clamped Inverter, PCC- Point of Common Coupling, PLL-Phase Locked Loop, PQ-Power Quality, PV-Photo Voltaic, RES-Photo Voltaic, SSSC-Static Synchronous Series Compensator, STATCOM-Static Compensator, UPQC-Unified Power Quality Conditioner

INTRODUCTION

To provide quality power has become today's most concerned area for both power suppliers and customers due to the deregulation of the electric power energy market. Efforts have been made to improve the power quality. Aspects on power quality can be classified into three categories that is, voltage stability, continuity of supplying power, and voltage waveform. The term custom power means the use of power electronics controllers for distribution systems. The custom power increases the quality and reliability of the power that is delivered to the customers. Customers are increasingly demanding quality in the power supplied by the electric company. One of the many solutions is the use of a combined system of shunt and series active filters like Unified Power Quality Conditioner which aims at achieving low cost and highly effective control. The UPQC is the most versatile and complex of the FACTS devices, combining the features of the STATCOM and the SSSC. The Unified Power Quality Conditioner is a custom power device that is employed in the distribution system to mitigate the disturbances that affect the performance of sensitive and/or critical load. several power quality problems related with voltage and current simultaneously therefore is multi functioning devices that compensate various voltage disturbances of the power supply, to correct voltage fluctuations and to prevent harmonic load current from entering the power system.

A Single stage three phase four wire grid-connected PV system with combined operation with a unified power quality conditioner (UPQC) is presented. The power circuit of the system, which is denominated PV-UPQC, is composed of two back-to-back connected neutral-point clamped (NPC) inverters. Thereby, series-parallel active power line conditioning, as well as injection of active power into the grid and load can be simultaneously performed**.**

Unified Power Quality Conditioner consists of two MOSFET based Neutral Point Clamped inverters (NPC), one shunt and one series cascaded by a common DC bus. The shunt converter is connected in parallel to the load. It provides VAR support to the load and supply harmonic currents. Whenever the supply voltage undergoes sag then series converter injects suitable voltage with supply. Thus UPQC improves the power quality by preventing load current harmonics and by correcting the input power factor. The UPQC can provide simultaneous control of all basic power system parameters, transmission voltage

The production of electrical energy from renewable energy sources (RES) has grown a lot in recent decades, mainly due to increased demand for electricity, as well as the global intensive efforts to overcome the harmful environmental impacts caused by pollutant energy sources, such as oil, coal, natural gas and others.

Normally, grid-connected PV systems can be deployed by means of single-stage or double-stage power conversion. Single stage PV systems are usually composed of only a grid-tied inverter (dc/ac converter). In this case, the PV array is directly connected to the dc-bus of the grid-tied inverter. On the other hand, in double stage PV systems, an additional dc/dc converter is placed between the PV array and the inverter. In this configuration, the maximum power point tracking (MPPT) is performed by the dc/dc converter. Considering single stage-PV systems, the task to perform the MPPT is assumed by the grid-tied inverter, combined with the advantage of achieving more efficiency when compared to double stage-PV systems. In both mentioned PV system topologies, the dc/ac converter

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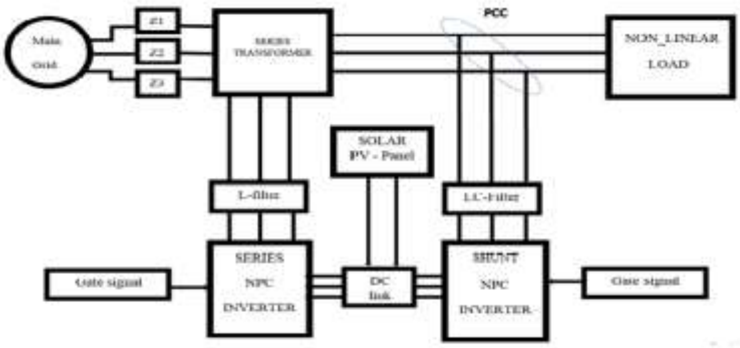
controls the amplitude of the currents injected into the grid, in order to guarantee the balance between the power produced to the PV array and that absorbed by the grid. MPPT is used to control the total dc-bus voltage at reference voltage, which is obtained from the MPPT technique based on Perturb and Observe (P&O).

NPC inverter is same as the other inverter which is to converts Direct current (DC) to Alternating current (AC) .The inverted current can be at any vital voltage and frequency with the use of pertinent transformers, switching, and control circuits. From the source like batteries, solar panel, wind turbine, or fuel cell the inverter will convert the DC electricity to AC electricity. In this modern technology, Power electronics is very important where it used in a great variety of product. With the high potential in high power for industry, multilevel inverter will become most popular for so many applications.

II. PROPOSED SYSTEM

A. BLOCK DIAGRAM



The various components using in block diagram are Distributed Energy Resource (DES), Grid, DC link Capacitor, Point of Common Coupling (PCC), NPC inverter, Filters The main objective of the project is to compensate the reactive power and real power in the transmission line. There are there are two different inverters are used series NPC inverter and parallel NPC inverter. It consists of a point of common coupling. The Distribution Energy Resource (DER) will be any resource such as wind, solar. Here we connect a solar across to the DC link. The main resource is connected to the unbalanced and non-linear load trough point of common coupling. The negligible amount of line impedance is present in the transmission line. The output of the DER is dc that converted into ac by inverter circuit. Even though the filter is used to get accurate ac sinusoidal wave.

B. CIRCUIT DIAGRAM

The complete power circuit scheme of the proposed S-S 3P4W grid-tied PV system is composed of two back-

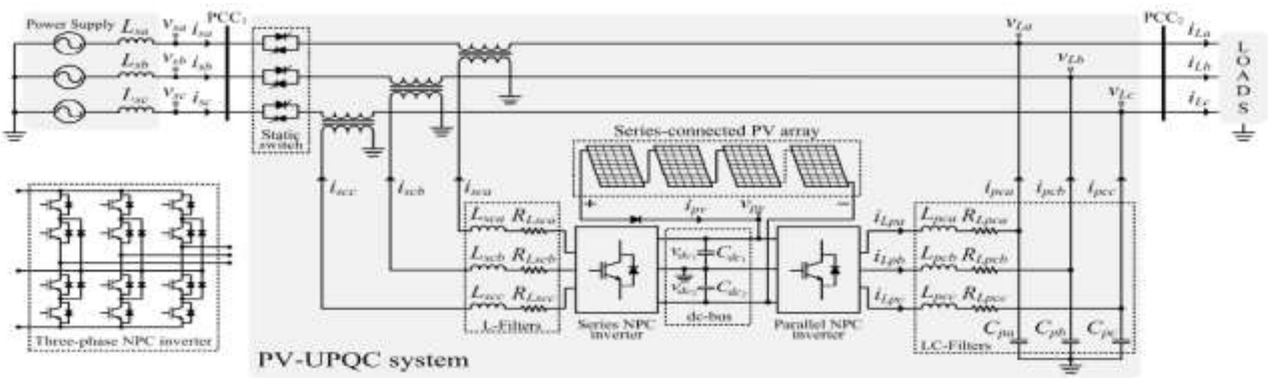


Fig 2. Complete Circuit diagram of proposed system

to-back connected NPC inverters and their respective passive filtering elements, and three single-phase coupling transformers employed to connect the series NPC inverter to the grid. The positive component is triggered to find out the reference current for both inverter in the topology. The gate pulses for the inverters are generated by the shunt and series controllers.

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III. UPQC WITH DUAL COMPENSATION STRATEGY

The dual compensation strategy applied to UPQC differs the conventional compensation strategy due to the parallel converter being controlled to operate as a sinusoidal voltage source providing balanced and regulated sinusoidal voltages to the load. As the parallel converter behaves as a sinusoidal voltage source, a low impedance path is achieved.

In this case, the flow of the load harmonic currents through the parallel converter is allowed. On the other hand, the series converter is controlled to operate as a sinusoidal current source, draining balanced sinusoidal currents from the utility grid. In this case, since a high enough impedance path is achieved, the flow of the load harmonic currents through the grid is blocked. In addition, both the sinusoidal voltage and current input references are in phase with the utility voltages. Thus, the series converter is responsible for indirectly compensating reactive power and unbalances of the load, as well as suppressing harmonic currents. Simultaneously, the parallel converter is responsible for regulating the output voltages and, indirectly compensating utility voltage unbalances and suppressing utility voltage harmonics. In this case, the utility voltage disturbances, such as voltage unbalances, sags/swells, and harmonics will always appear across the single-phase series transformers. Furthermore, the input references are continuous in the dq synchronous rotating frame, due to the controlled quantities of current and voltage being sinusoidal in the abc stationary frame. This allows the use of the classical proportional-integral discrete (PID) controllers with null errors in steady state.

IV.CONTROL STRATAGEY FOR UNIFIED POWER QUALITY CONDITIONER

A. DQ TRANSFORMATION

It is established that the active filter flows from leading voltage to lagging voltage and reactive power flows from higher voltage to lower voltage. Therefore both active and reactive power can be controlled by controlling the phase and the magnitude of the fundamental component of the converter voltage with respect to line voltage. DQ theory provides an independent control of active reactive power by controlling phase and the magnitude of the fundamental component with respect to converter voltage. According to the dq control theory three-phase line voltages and line currents are converted in to its equivalent two-phase system called stationary reference frame. These quantities further transformed into reference frame called synchronous reference frame. In synchronous reference frame, the components of current corresponding to active and reactive power are controlled in an independent manner. This three-phase dq transformation and dq to three-phase transformation are discussed in detail in this chapter. The outer loop controls the dc bus voltage and the inner loop controls the line currents.

B. BASIC CONTROL FUNCTION

It is evident from above discussion that UPQC should separate out the fundamental frequency positive sequence components first from the other components. Then it is required to control both series and shunt active filter to give output. The control strategy uses a PLL based unit vector template for extraction of reference signal from the distorted input supply.

C. SHUNT CONTROLLER

The STATCOM controller has the capability of independently controlling the shunt real and reactive power components. In the automatic voltage control mode, the shunt converter reactive current is automatically regulated to maintain the trans-mission line voltage to a reference value at the point of connection. However, the shunt real power control is dictated by the dc voltage controller, which acts to maintain a preset voltage level on the dc link, thereby providing the real power supply or sink needed for the support of the series voltage injection, inner current controller is considered particularly suitable for current source rectifier due to its safety, stability performance and fast response. Typically the inner current control loop is at least ten times faster than the outer loop controlling the dc voltage. The I_{dref} obtained from the voltage controller is compared with the actual d-axis current and stabilized through PID controller to get the equivalent d-axis reference voltage v_d. Similarly the actual q-axis current is compared with I_{qref} and the error so obtained is stabilized through PID controller to get the equivalent q-axis reference voltage v_q.
The parameters of these PID controllers are tuned and fine adjustment is carried out by trial and error procedure to minimize the performance indices, namely the integral square error and integral time absolute error so as to give the best response. The reference voltages v_d and v_q are compared with actual v_d and v_q to obtain the equivalent v_{dav}, and v_{qav}. Then these two-phase quantities are converted into three-phase quantities using dq-abc transformation. These three-phase voltages are fed as control signals to the PWM modulator for developing the switching pulses to the current source rectifier switches.

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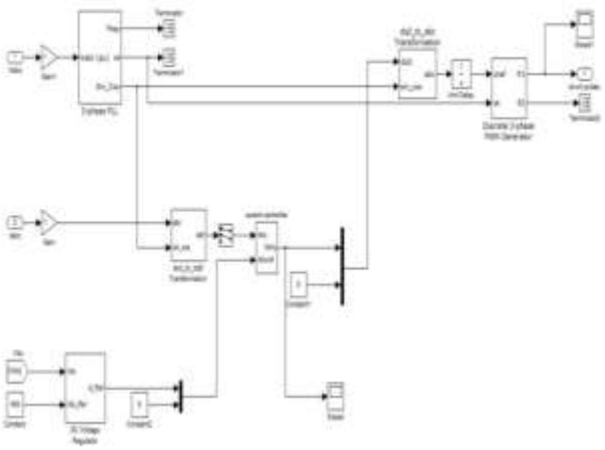

Fig 3 Shunt Controller

D. SERIES CONTROLLER

A Series converter is a solid-state voltage source inverter, which generates a controllable AC voltage source, and connected in series to power transmission lines in a power system. The injected voltage (v_q) is in quadrature with the line current I, and emulates an inductive or a capacitive reactance so as to influence the power flow in the transmission lines

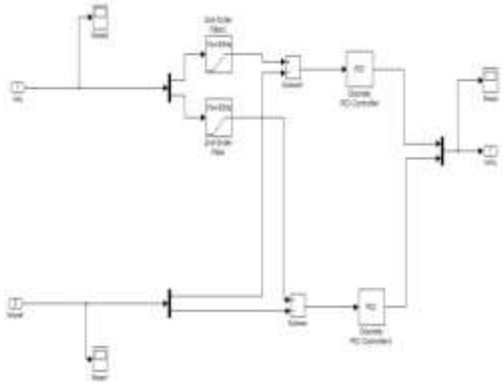

Fig 4 series controller

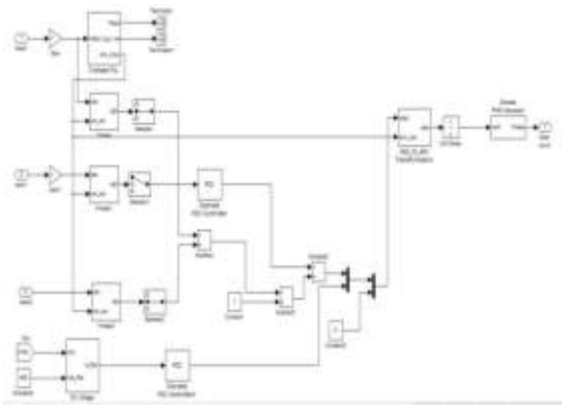

Fig 5 Inner Current Controllers

The compensation level can be controlled dynamically by changing the magnitude and polarity of v_q and the device can be operated both in capacitive and inductive mode. A phase-locked loop (PLL), which synchronizes measured positive-sequence component of the current with self generated current. The output of the PLL ($\theta = \omega t$) is used to compute the

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direct-axis and quadrature-axis components of the AC three-phase voltages and currents. Sequence of voltages v_1 and v_2 as well as the dc voltage v_{dc}. AC and DC voltage regulators which compute the two components of the converter voltage required is obtaining the desired dc voltage and the injected voltage.

V. RESULTS

The UPQC system operates in three different modes based on the different triggering process of the three phase circuit breaker. The simulation diagram consists, three circuit breakers , one for transmission line, another two for STATCOM and SSSC triggering process. In this simulation the frequency range is 50Hz, the transition time for the transmission line circuit breaker is (4/50) s to (8/50) s and the time for controller circuit breaker is [4/50] sec to [10/50] sec.

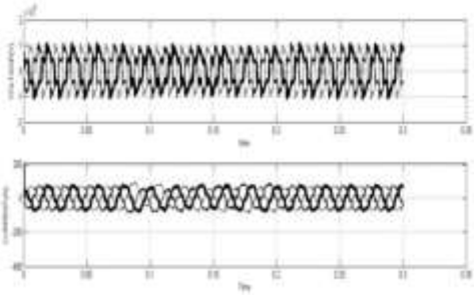

Fig 6 Input voltage and input current (50 HZ)

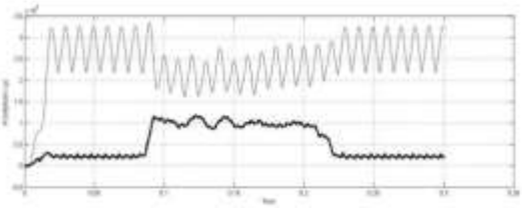

Fig 7 Input Power for 50 HZ.

So the different triggering process gives the three different outputs. The three operating modes are performed in the three different time region. They are

(0.00 to 0.08) sec = Normal operation mode
(0.08 to 0.16) sec = STATCOM & SSSC breaker only ON
(0.16 to 0.20) sec = UPFC mode (three breakers are gets turned on)

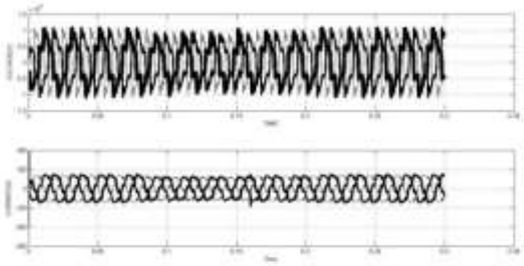

Fig 8 Output Voltage and Output Current (50 HZ)

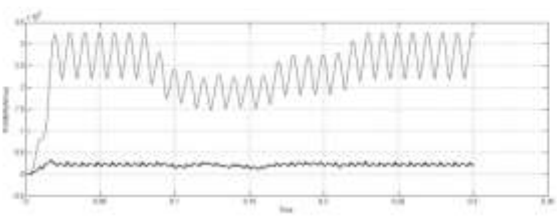

Fig 9 Output Power (50 HZ)

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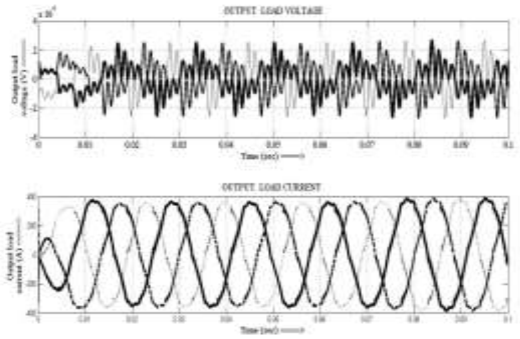

Normal Operation Mode

The time period (0 to 0.08) for the utility voltage and current operations. In this period the voltage amplitude and current amplitudes are in $1.1e^4$ and 100 A respectively.

Second Mode

The time period (0.08 to 0.16) sec the STATCOM & SSSC breaker only gets turned on. Due to the breakers on the voltage gets raise up. In this mode due to the STATCOM & SSSC breaker ON conditions produce.

Third Mode

The time period (0.16 to 0.2) sec, three breakers are gets turn on in this period, so the reactive power is smoothen in this transition section. After that operation the first mode is followed by the transmission system.

A. RESULT FOR 60 (Hz) OPERATION

The same modes of operations are performed for the 60Hz operation. The output for the 60Hz operation is shown in figure (5.14) and (5.15).In this output the mode 1,2 & 3 are performed as same as the 50 Hz operation. The UPQC control region takes place in (0.2 to 0.8) sec, in this transition time period the reactive power is reduced the real power is improved and thus the transmission system is compensated effectively.

B. OUTPUT WAVE FORMS FOR 60 (HZ)

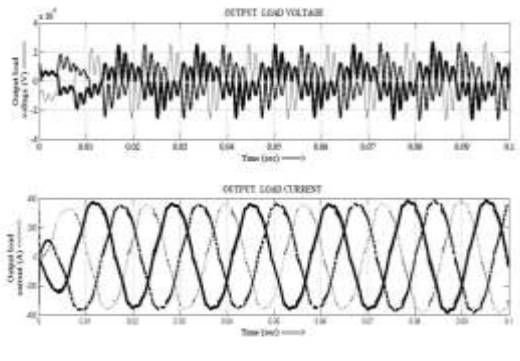

Fig 10 Output voltage & Output current for 60 (Hz)

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