Enhancement of power quality in solar power using UPQC technique

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Abstract : The need to provide pollution free electricity has encouraged a rise in the use of solar energy grid connections. As a result, voltage harmonics and voltage distortion develop when a solar panel is connected to the grid, both of which are power quality concerns. Active power filters are an important method for reducing harmonics. The objectives of this paper is to integrate series active and shunt active power filters into a single unified power quality conditioner (UPQC). Its principal function is to compensate the voltage imbalance, reactive power, negative sequence current, and the harmonics. The compensation theory and control technique of the UPQC are thoroughly discussed in this paper. An approach based on unit vector template control with a phase locked loop based control algorithm is used in this approach to control the solar grid linked with the unified power quality conditioner. The system's performance will be thoroughly validated using MATLAB simulation, which will address load fluctuation, transient response, total harmonic distortions, voltage swell, and sag, among other things. The IEEE standard range of Total Harmonic Distortions is achieved using the specified grid integration of solar systems employing a single phase unified power quality conditioner.

IndexTerms - Energy storage system, UPQC, grid stability, power improvement and harmonics.

I. INTRODUCTION

Over the last few years, the phrase "power quality" (PQ) has gained a lot of exposure. Most power electronics-based devices can now be realised on a commercial platform, thanks to advancements in semiconductor device technology [1]. With the advancement of power electronic technology, it is now possible to create a variety of Flexible Alternating Current Transmission Systems devices that provide high-quality electric energy while also improving power system control. One of them is UPQC [2]. Unified power quality conditioners (UPQCs) are devices that integrate series active and shunt active filters into a single unit. The primary role of a UPQC is to adjust for supply voltage imbalances, reactive power, negative-sequence current, and harmonics [3, 4]. UPQC can increase power quality at the point of installation on power distribution or industrial power systems, to put it another way. As a result, the UPQC is expected to be one of the most effective solutions for large capacity loads prone to supply voltage imbalance [4]. Solar, wind, tidal, and other renewable energy sources are being used to replace traditional energy sources. Furthermore, because RESs are clean, accessible, and abundant in nature, their use is quickly increasing [5]. Furthermore, when RESs are implemented, a favourable situation such as reduced global warming and reduced carbon dioxide emissions has been found. As a result, renewable energy sources are regarded as preferable to traditional sources. Renewable energy sources can also be included in the current power grid to meet the increased load demand [6]. Solar and wind energy resources, despite their numerous advantages, are very vulnerable to weather and geographic location, which are the two most important downsides of using renewable energy sources. These drawbacks have a greater influence on grid stability, which can be reduced by combining RESs with ESSs. The cited study [7]–[9] discusses the several issues about RESs as well as the process for addressing them. Uncertainty in photovoltaic systems causes total harmonic distortion in the grid. The load voltage and current are altered as a result. THD and voltage stabilisation difficulties have been addressed using flexible AC transmission system devices [10]. When compared to other power electronic-based FACTS approaches, the UPQC outperforms the rest. The UPQC increases the majority of the required characteristics, such as voltage, harmonic mitigation, and current, as well as the overall power quality of the system. They've been used to eliminate the impact of non-linear load induced harmonic currents on power systems [11, 12].

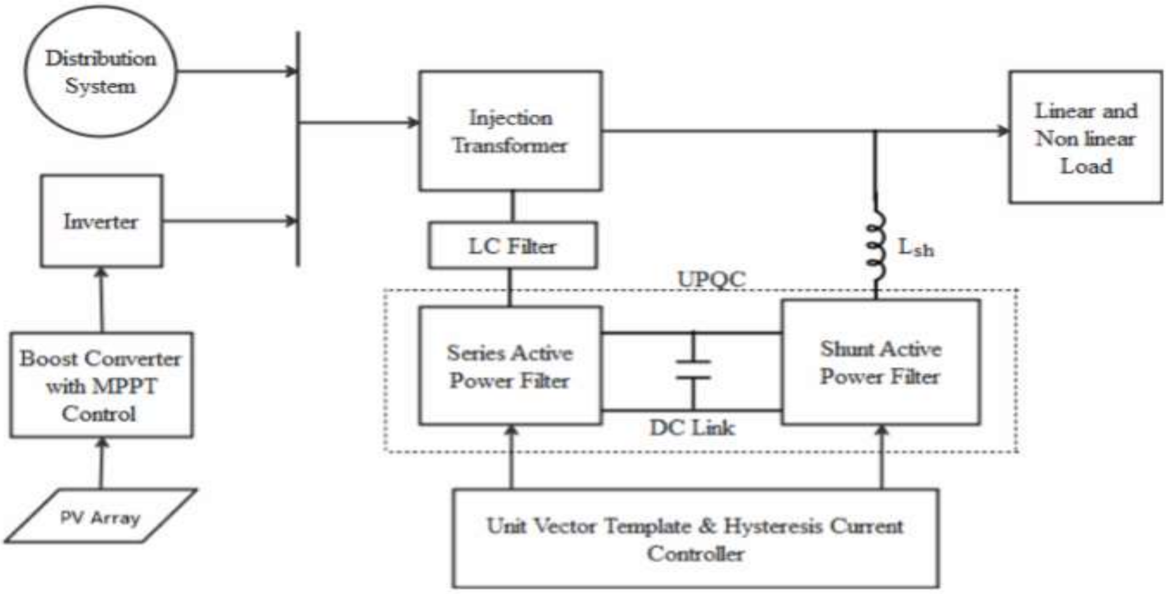

Fig 1: solar grid connected system.

II Literature survey:

In this context, solar energy is the most useful of the several renewable energy sources accessible. The solar energy utilisation grid can be injected using systemic energy conversion circumstances after converting electrical energy with photovoltaic arrays. Typically, DC-DC converters are used for this purpose. The PV framework's voltage has been increased, and it is now connected to the power grid. The DC transition stage on many PV systems is turned off, and the energy from the PV clusters is safely pumped into the grid via a DC/AC converter. Because the DC output of the PV module necessitates the usage of power electronics converters to convert the DC power to the AC grid interface, a DC-AC inverter is required. A fractional order controller for grid photovoltaic systems is proposed in, and an atypical solar system working in an independent grid linked mode is described as an effective solution for energy supply challenges in the residential sector in. The PI controller should be used by most researchers to improve performance in the UPQC configuration, albeit due to the non-linear nature of the system, this will reduce performance. It is investigated the performance of UPQC, a common DC bus capacitor with a mix of parallel and series active power filters. Combination mode control modifies UPQCs and left shunt inverters when linked to a distribution system to minimise power quality difficulties caused by non-sinusoidal electricity. In non-linear load scenarios, a DSP based shunt active filter is utilised to reduce harmonics and modify reactive power. In grid connected PV systems, the measures outlined above do not totally fix power quality issues. As a result, this study presents a single phase PLL based on quadrature signals generated by propagation delay. The old method's fundamental fault is that the delay time is calculated using a constant frequency assumption, which makes it subject to phase bandwidth fluctuations. In addition to the MPPT and phase synchronous control, a second controller is required when the solar DC bus is linked to the grid. As a result, this research uses a single phase unified power quality conditioner based on a unit vector template control algorithm for activities crucial to solar grid integration, such as voltage sags, unit power factor correction, and voltage and current harmonic elimination.

III Methodology:

To convert the solar DC voltage to an AC voltage the single phase inverter uses the pulse width modulation technology at the frequency of the line. To ensure that the DC voltage remains constant a software is used. To build the phase locked loop the PID controller is used. To fully meet the standards of regulation the direct operations of the active filters is maintained in the proposed method.

3.1 Using permutation and observation to track the maximum power points:

To increase the efficiency of the generation of solar power the MTTP method is used. The boost converter circuit functions as an impedance coordinating device by adjusting the obligation cycle between the information and the yield. The voltage obtained from the boost converter depends on its applications. To determine the output voltage the maximum power point theorem is used. The permutation and observation technique is used to get more power.

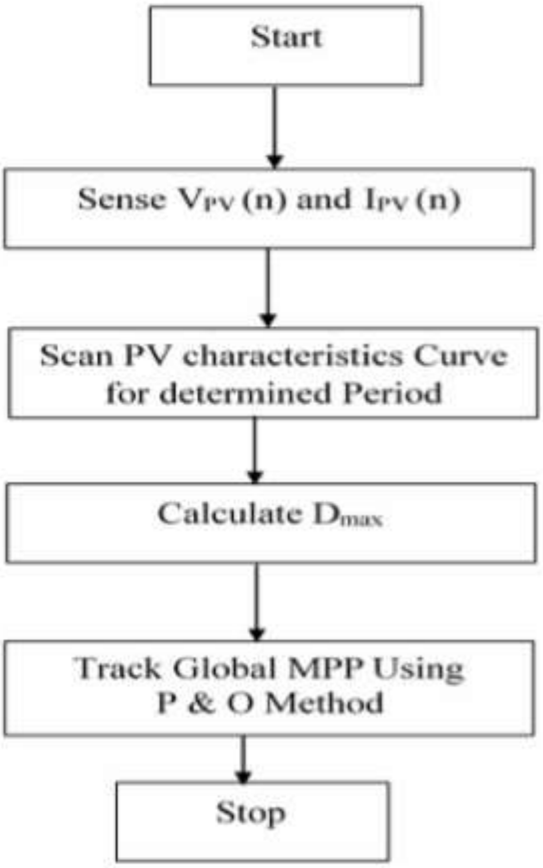

Fig 2: Permutation and observation method flowchart

3.2 The voltage source inverter:

The inverter uses pulse width modulation to generate a sinusoidal voltage. In most circumstances, the grid connection point filter is little more than an inductance that modulates the grid current's first harmonic. The inductive coil's active resistance, conductors, and the power bridge's transistors' resistances all have a role.

$$V_Z = V_{inv} - V_{grid}, I_{out} = \frac{V_{inv} - V_{grid}}{Z} \quad (1)$$

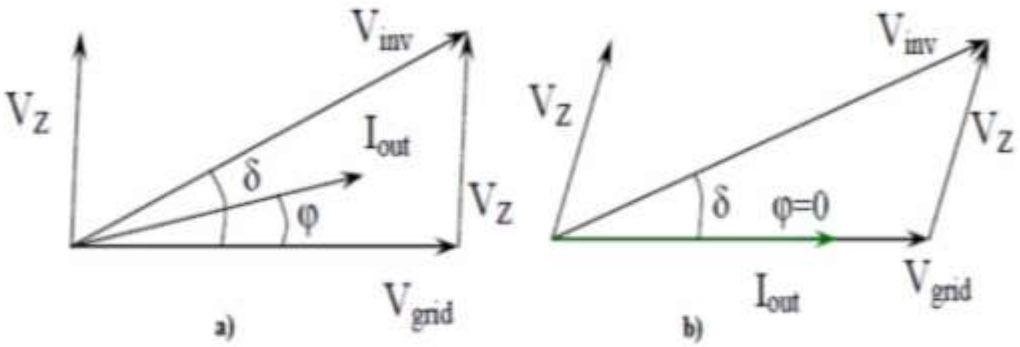

Fig 3: Single phase diagram for current and voltage

3.3 Single phase UPQC:

The suggested control technique intends to produce a voltage reference signal in the PCC. As a result, the simplest way to design a series of converters with can be done by matching the input to the load bus voltage sine curve directly. The power supply voltage may be twisted due to unfavourable conditions in a matched feeder, resulting in a voltage rise. The shunt APF's primary function is to maintain a constant DC voltage, which stabilises current synchronisation and reactive power. The easiest technique to compensate for the aforementioned load issues is to force a sinusoidal wave in the source current.

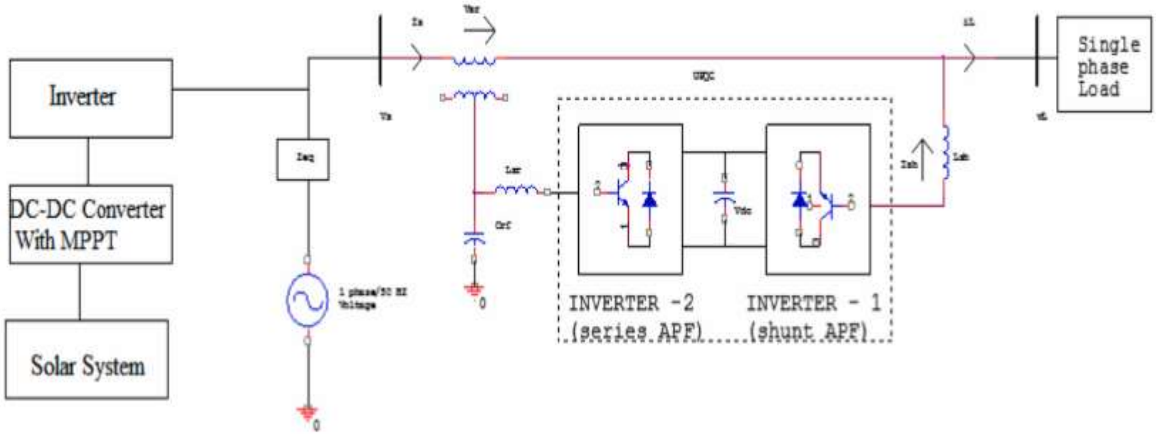

Fig 4: The functional diagram of the proposed system.

3.4 UPQC's control strategy:

The presence of supply voltage distortions are identified by using two orthogonal unit vectors. It can be done by multiplying the output by using the predicted peak phase formula. The sinusoidal voltage is given below

$$V^*_s = V^*_{im}[\text{lsinwt}] \quad (2)$$

The aggregation of essential and higher constant segments can be reduced by using the voltage. The voltage change is scientifically conveyed as a result of the non-linear load that is created.

$$V_s(wt) = V_{sf} + V_{sh} \quad (3)$$

The above equation can be further expressed as,

$$V_{s\ a,h} = \sum_{n=2}^{\infty} V_{s\ a,h}(nwt + \theta_{na} \quad (4)$$

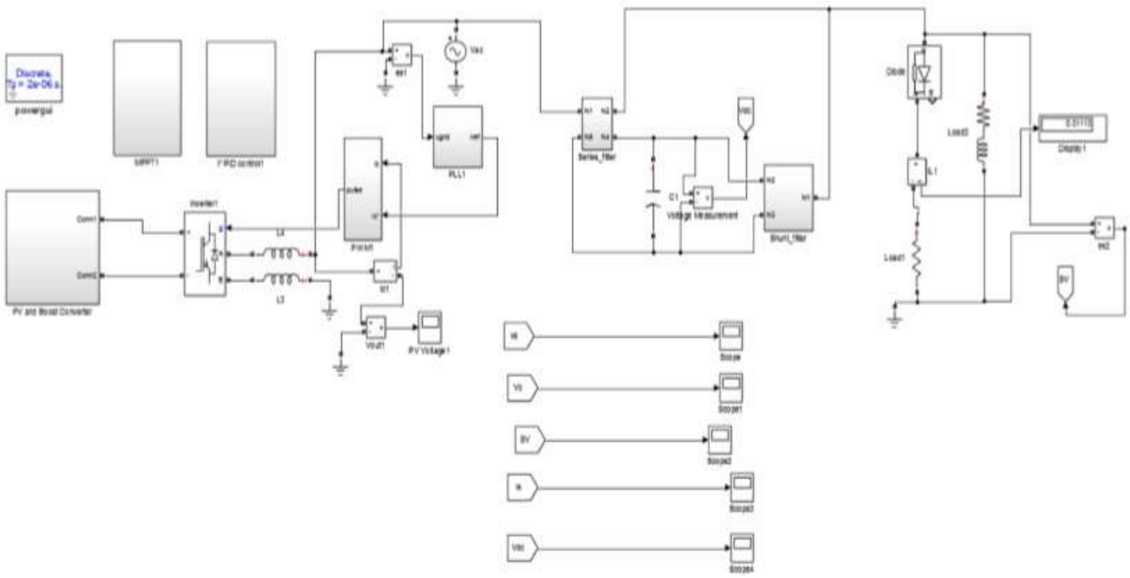

Fig 5: Simulation model with UPQC

3.4.1 Shunt control strategy:

The current and reactive power adjustment is provided by the shunt active power filter. It works as a controlled current generator, balancing load current and driving network source currents in phase with positive sequence system voltages.

3.4.2 The series control strategy:

The voltage compensation is offered by the series active power filter. The voltage compensation generated is synthesised by the pulse width modulation converter and connected in series with the voltage supply to balance and make the PCC voltage sinusoidal.

3.4.3 The DC voltage regulator:

The direct current voltage will change during the compensation process because of the compensation of the active power and switch losses in the UPQC. If the rating value and the DC voltage are not same the compensation value will not match the output voltage of the series active filter. Then compensation cannot be applied. The same way is the working of the shunt active filter.

3.5 The hysteresis controller:

The actual load voltage and the reference load voltage are compared. By reversing the pulse switching the lower switches will get the switching pulse. To activate the operations of the pulse width modulation, the reference source generated from the current signal is compared to the current value of the real source. The hysteresis controller allows the inductor current to vary between two extreme points. This current variance causes low frequency ripple current, which can only be handled by a quality filter circuit.

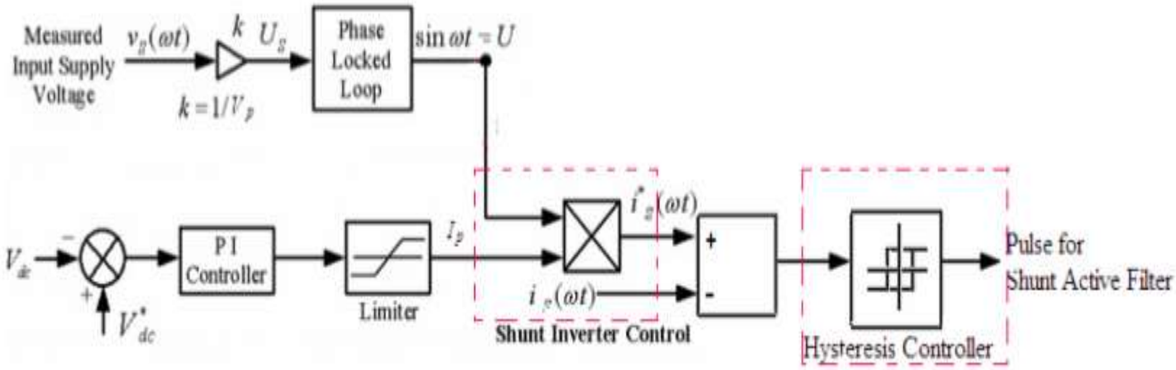

Fig 6: Hysteresis controller block diagram

IV Performance analysis:

To get the most power, the permutation and observation technique is applied. It is accomplished by the usage of a unit vector template. The converter's output voltage is high when compared to the solar voltage. The power factor in this project was one since the source current and voltage were in phase. The THD value of the suggested system in this study employing the unit vector template matching method is 4.66 percent, which is within IEEE standards. The recommended system achieves the best outcome. Template matching with UPQC has a THD of 4.66 percent, while template matching without UPQC has a THD of 55.27 percent.

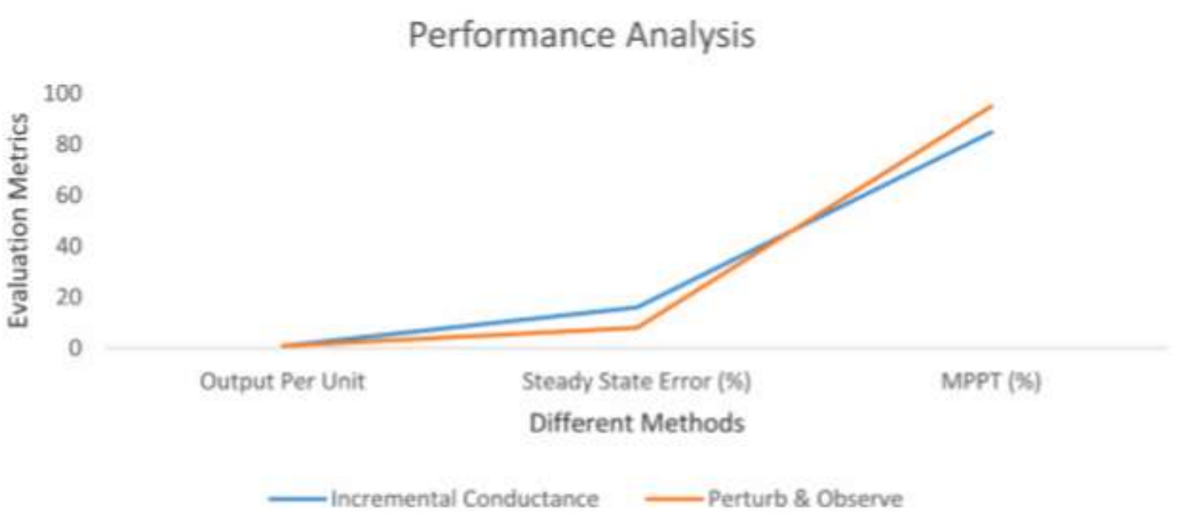

Fig 7: Performance analysis of the proposed method

Conclusion:

This paper discusses how the electrical supply network's power quality can be improved. The active filter series was designed to compensate for harmonic disrupting voltages, as well as voltage sags and swells. Finally, UPQC was offered as a generic approach for compensating all voltage and current disturbances. The simulation results revealed that the UPQC can be used to compensate all the voltage and current disturbances with high efficiency. The simulation results are compared with the test results. The proposed UPQC technique delivers the best results in all parameters. The proposed grid integration solar system is within the IEEE standard range because the overall harmonic distortions are less than 5%.

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