ISSN: 2319-345X

IJMRBS

International Journal of Management Research and Business Strategy

www.ijmrbs.org

E-mail
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International Journal of Management Research and Business Strategy

ISSN 2319-345X www.ijmrbs.com

Vol. 10, Issuse. 1, January 2022

MODIFIED P-Q THEORY BASED CONTROL OF SOLAR PV INTEGRATED UPQC-S

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Abstract— The development of non-linear loads in electrical energy processing applications such as switched mode power supplies, electric motor drives, battery chargers, etc., has a significant impact on the quality of electric power. It is becoming more and more important to use bespoke power devices like UPQC since they provide the best answer for all power quality challenges. P-Q theory control of PV arrays combined with unifying power quality conditioners is proposed in this research (PV-UPQC-S). Clean energy production and power quality enhancement are also part of the system, boosting its overall usefulness. As part of the p-q theory-based control, voltages at the point of common coupling (PCC) are utilised to extract fundamental frequency positive sequence (FFPS) components using the generalised cascaded delay signal cancellation (GCDSC) approach. With this change to the p-q theory, it is possible to use PV-UPQC-S control in situations when the PCC voltages are distorted. Under normal grid circumstances, the PVUPQC-series S's voltage source converter (VSC) shares some of the load's reactive power. This raises the series VSC's use while decreasing the shunt VSC's rating. The PV array is connected into the UPQC's DC-bus, which reduces demand on the supply system by providing some of the active load power. Matlab-Simulink simulations with linear and nonlinear loads show that the PV-UPQC-S, based on modified p-q theory, has excellent dynamic performance. To demonstrate the PV-UPQC-efficacy, S's we ran simulations and found that the source current had a tolerable THD and the load voltage remained at its nominal value.

Index Terms— There is a lot of talk about power quality, UPQC-S and solar MPPT.

I. INTRODUCTION

Under typical working situations, power quality is defined as a collection of criteria that describe how power quality is given to the end user.voltage characteristics and continuity of supply (frequency, magnitude, waveform and symmetry). Customers who are sensitive to root mean square (RMS) voltage changes and transients need a degree of power quality that can only be provided by specialised power devices, which use power electronic or static controllers in medium or low voltage distribution systems. An energy storage module or a master control module may be used to conduct voltage regulation and interruption of current in a distribution system to enhance the quality of the power it delivers.A CP device is often used to regulate voltage, perform active filtering, distribute load throughout a system, or rectify the power factor. Engineers' attention has recently been drawn more and more to Unified Electricity Quality Conditioners, which provide clients with high-quality power. Shunt (APF) and series

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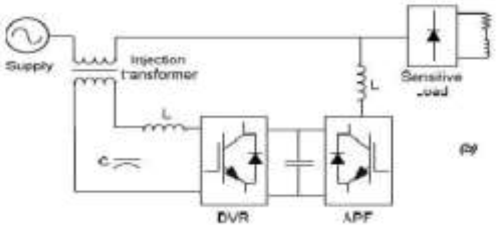
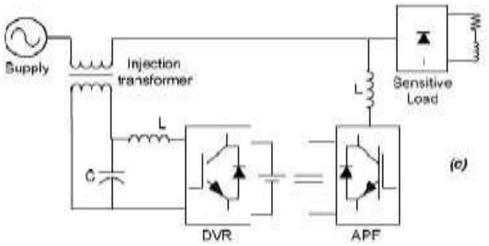
compensator (DVR) are combined to form UPQC through a common DC link capacitor, which is linked to both. Protecting sensitive process loads and increasing service dependability are the primary goals of these devices, which compensate for power quality disturbances such as current harmonics. However, since they increase power quality for all end users, these devices prevent local distributors from guaranteeing differing quality demand levels to final consumers. Additionally, the cost of installation is extremely costly compared to the power quality level that may be achieved.

Because it automatically calculates load active and reactive powers, which are critical for reactive power sharing in series VSC, p-q theory-based control is the best choice for PV-UQPC-S control. Under distortion or imbalance, the conventional p-q theory produces inaccurate conclusions while just requiring basic calculations. Using fundamental frequency positive sequence (FFPS) voltages, p-q theory may be used to estimate the reference currents. Proposals have been made for a new theory of phase-locked loops (PLL). Many alternative techniques exist for obtaining fundamental frequency positive sequence voltages, including the use of notch filters, second order generalised integrators (SOGI), generalised cascaded delay signal cancellation (GCDSC), and so on.

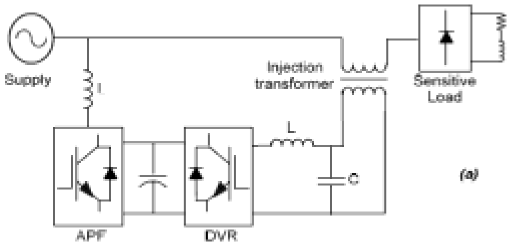


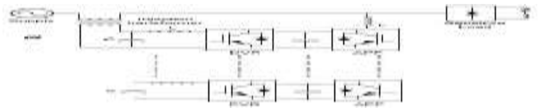


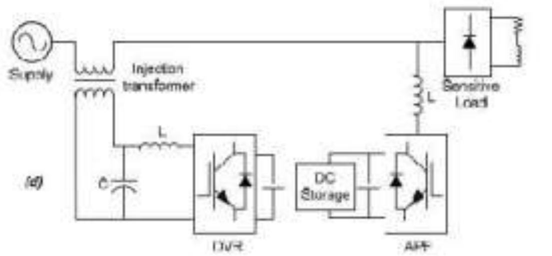
There are many filter blocks for each harmonic component in techniques using adaptive notch filters, which means the reaction time is slower and the settling period is shorter. Minor deviances from the tuned frequencies severely impair the performance of SOGI-based approaches. The harmonic attenuation properties have been enhanced using GCDSC-based approaches. Using Matlab-Simulink, the dynamic performance of the proposed modified p-q theory-based PV-UPQC-S is investigated under varying irradiation, voltage sags/swells, distortions, load imbalance, etc.

II. POWER CIRCUIT TOPOLOGIES OF UPQC

It is possible to share the active power using UPQC, which combines an Active Power Filter (Shunt) and a Dynamic Voltage Restorer (Series Compensation) coupled through a shared DC link capacitor. IGBT inverters are used in each compensator, which may be operated in either current or voltage mode. UPQC models may be referred to as right shunt-UPQC or left shunt-UPQC depending on where the shunt compensator is located in relation to the series compensator. It is common practise that the active power created in one unit is used in the other unit in order to maintain energy balance. The right shunt-UPQC has better overall characteristics than the left shunt-UPQC. Figure 1 depicts the basic UPQC topologies.







A variety of power circuit topologies are shown in Figure 1. If you're looking for something that's easy to set up and doesn't need a lot of technical knowledge, then this is the solution for you.

For medium voltage and low voltage applications, UPQC may be employed A UPQC is unnecessary in low-power applications since the DVR spends the majority of its time in standby mode. The majority of UPQC systems are 3-phase 3-wire (3P3W) configurations. In a 3P3W system, the neutral of the series transformer used in the series component UPQC is regarded to be a fourth wire for the 3P4W system, which is also possible. UPQC systems in a single phase are also available. For UPQC applications, a variety of topologies, including multilevel topology, single-phase UPQC with two half-bridge converters, H bridge topology, and single-phase UPQC with three legs, are being investigated. A DC/DC converter and a super capacitor form a novel architecture. There isn't a common DC connection between the units in series and parallel. The development of a distributed power generating system based on advanced renewable energy is underway. One feeder's bus voltage is regulated while the voltage across a sensitive load in the other feeder is regulated by the UPQC. Unified power quality conditioners (UPQCs) have been suggested to simultaneously compensate voltage and current in neighbouring feeds. Critical and sensitive loads in two-feeder systems may be completely protected by the MC-UPQC topology compared to standard UPQC. The safety net

address the protection of a UPQC against damage or malfunction caused by voltage spikes and short circuits that occur during operation. Common energy storage, DC/AC converter, LC filter, and injection transformer make up the UPQC power circuit.

III. **SYSTEM MODELING**

Figure 2 depicts the PV-UPQC-S structure. A series VSC and a shunt VSC are coupled through a shared DC-bus to form the system's core. Inductors are used to link the VSCs to the PCC. A ripple filter is used to remove harmonics from the VSCs' switching frequency ranges. A series injection transformer injects voltage into the series VSC. Through a reverse blocking diode, the UPQC's DC-bus is directly linked to the PV array. PV-UPQC-S phasor diagram with linear reactive load is shown in Fig. Reactive power is solely shared by the shunt VSC when the subscript '1' is used, however the subscript '2' is used when the series VSC also distributes reactive load power. When the series VSC is not injecting any voltage, the PCC voltage (VS1) and the load voltage (VL1) are in phase. The load current (IL1) and the load angle () are pre-series compensated. Additionally, the PV array's true power, denoted as, is injected through the shunt VSC (IPV). Power from the grid is used for the remainder of the load (IS1). Phase-shifted sum of PV array current and reactive load current (ISH1) before series VSC injection (ISH2) is the shunt current (ISH1). current.

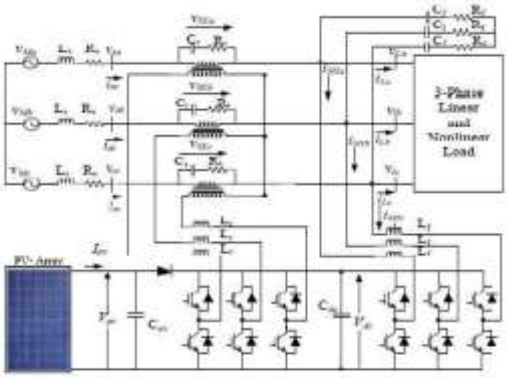


Fig. 2. Structure of PV-UPQC-S

Voltage (VSE) is injected into the series VSC when a portion of reactive power needs to be shared via series VSC (VL2). This shifts the load current to the other side (IL2). VSC current drops to a minimum because the active current taken from the grid (IS1=IS2=IS) remains constant (ISH2). Power angle () causes the series VSC to take up some of the load from the shunt, resulting in an increased utilisation rate for the series VSC.

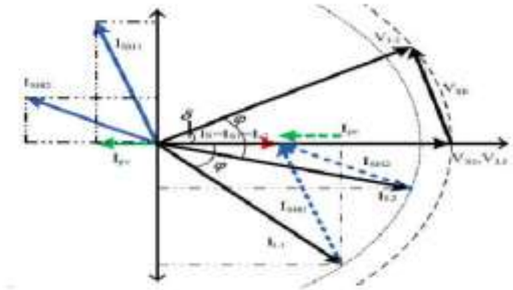
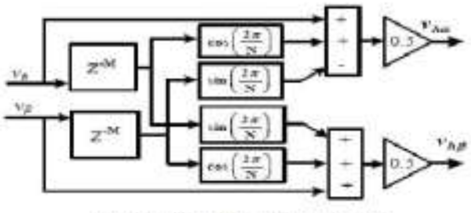


Fig. 3. Phasor Diagram of PV-UPQC-S

Reactive power sharing via series VSC results in lower series VSC voltage VSE under sag conditions than during swell conditions for the same amount of reactive power sharing. In a sag state, the grid current IS is greater than it is when the load is constant. As a result of these findings, the control applied is designed to correct for reactive power during sag and nominal situations in order to avoid excessive VA rating of series VSC. At least 30% of the active electricity is supplied by a PV array intended to meet these needs. Due to a reduction in the amount of grid current required to support a fixed series VSC voltage rating, the reactive power sharing capacity of the PV array decreases when more active power is given to the load.

PVUPQC-S is controlled by four different control blocks. It includes GCDSC blocks for shunt and series VSC control as well as load power calculation blocks.

Figure 4 depicts the mathematical implementation of the DSC operator (a). zM where M is the number of delay samples that correspond to the delay factor N may be seen in the image. The delay signal operator blocks with delay factors N = 2, 4, 8, 16, 32 are often advised when the harmonic content of the PCC voltage is not known. As seen in Fig. 4, this system of cascading blocks is known as the GCDSC block (b).



(a) Delay Signal Cancellation Block-N

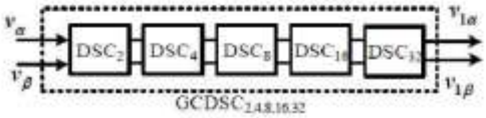
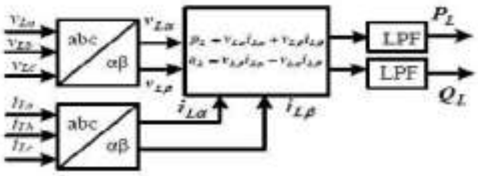


Fig. 4. Fundamental Frequency Positive Sequence Extraction using Generalized Cascaded Delay Signal operation

Pre-filtering utilising the GCDSC block may make the system frequency-adjustable, as in the case of GCDSCPLL. An attenuation of 0.065% and phase inaccuracy of 3.43° may be achieved when the frequency is set to 50 Hz in the GDSSC.. Only a tiny amplitude and phase inaccuracy is caused by the grid fundamental frequency fluctuation of 49.3 to 50.2 Hz. As a result, frequency adaptation may be avoided, which saves the system from having to deal with extra complexity.

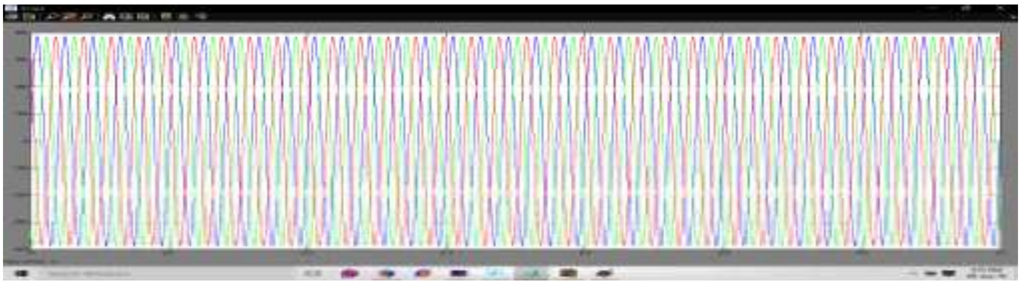
Instantaneous active and reactive load powers are computed using p-q theory in this block Figure 5 depicts the load power calculation block diagram. Voltage (vLa, vLb, vLc) and current of loads are transformed into power invariant Clarke transform of domain load voltage (Vl), power invariant Clarke transform (Vl), and current of loads (Il), current of loads. The basic active and reactive powers PL and QL are obtained by passing the instantaneous active and reactive powers pL and qL through a low-pass filter (LPF



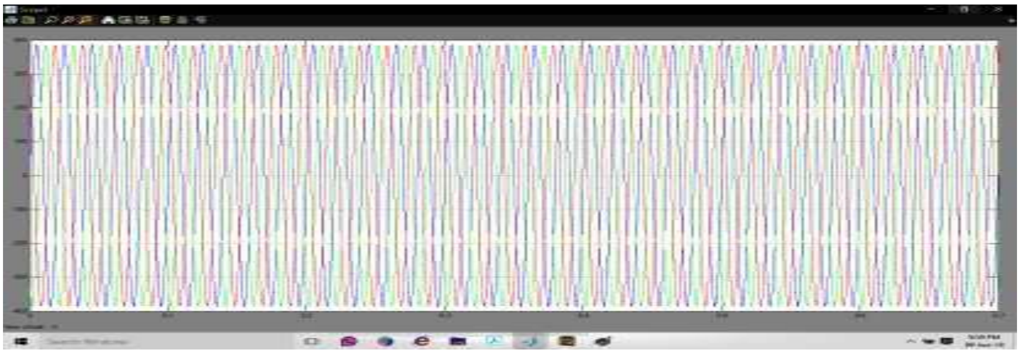
IV. SIMULATION RESULTS

Sim Power Systems blockset in Matlab/Simulink software is used to mimic the dynamic behaviour of PV-UPQC-S under dynamic situations. Variations in PCC voltages, irradiation, and load imbalance are all used to test the dynamic performance. Nonlinear and linear loads are combined in the load.

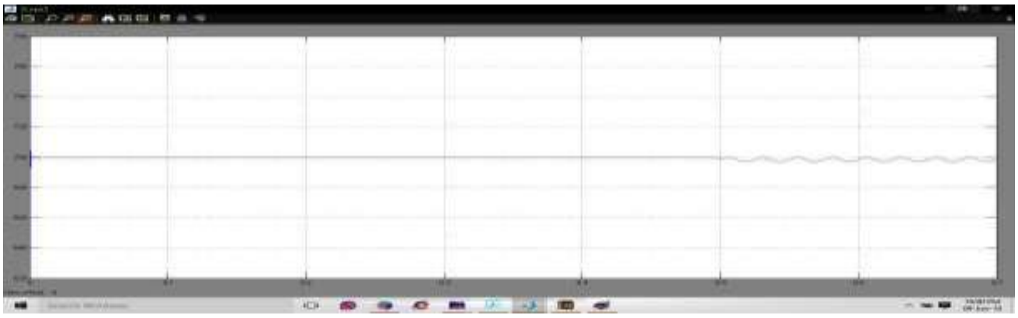
CASE-A: PV-UPQC-S PERFORMANCE UNDER LOAD UNBALANCE CONDITION



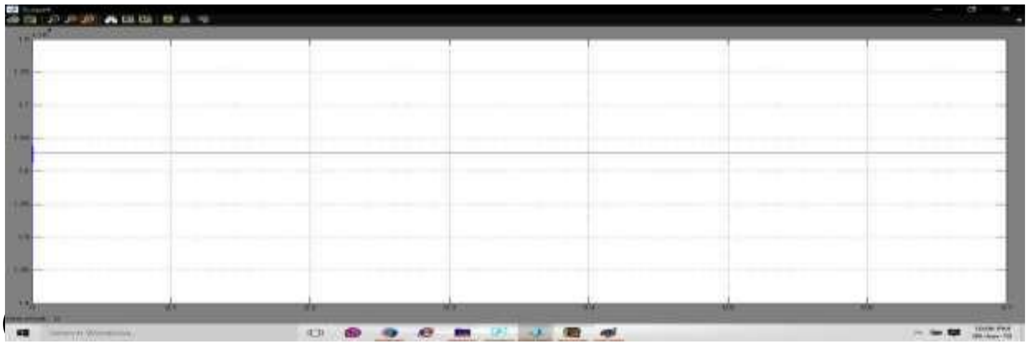
(a) PCC voltages



(b) load voltages



(c) DC bus voltage



(e) load currents

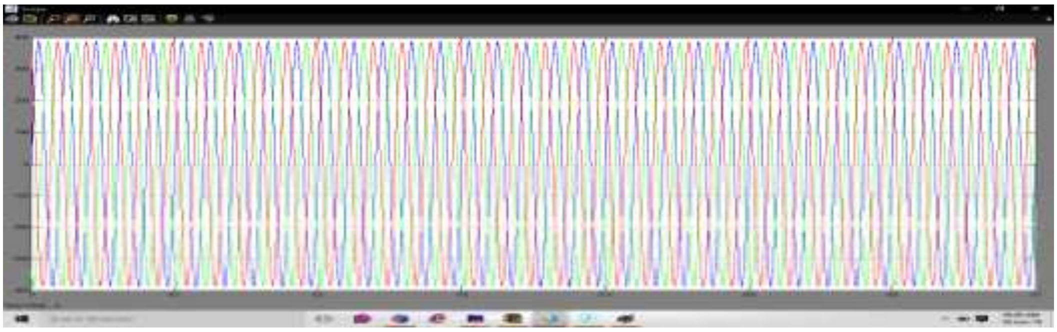
(f) shunt VSC currents

(g) **PV array power**

Fig:6. PV-UPQC-S Performance during Load Unbalance Condition

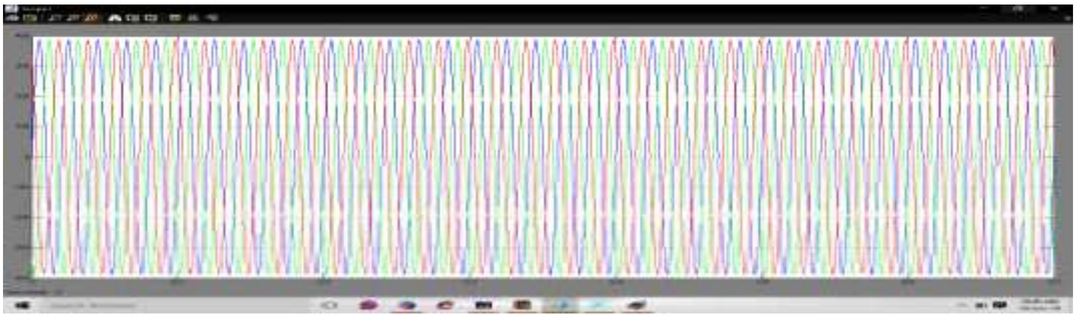
Figure 6 depicts the PV-UPQC-S performance in the event of a load imbalance. PV array power (iSH), shunt VSC currents (iL), grid currents (is), load voltages (vL), DC-bus voltages (Vdc), and PCC voltages (vs) are all shown (Ppv). A nonlinear load that is out of phase with the rest of the system is created when the load's phase 'b' is disconnected at 0.51 s. The shunt VSC of PV-UPQC-S ensures that the grid currents are maintained at unity power factor by balancing them. Within 0.04 s of a 20 V overrun, the DC-bus voltage returns to its regulated value of 700 V.

CASE-B: PV-UPQC-S BEHAVIOR DURING IRRADIATION CHANGE

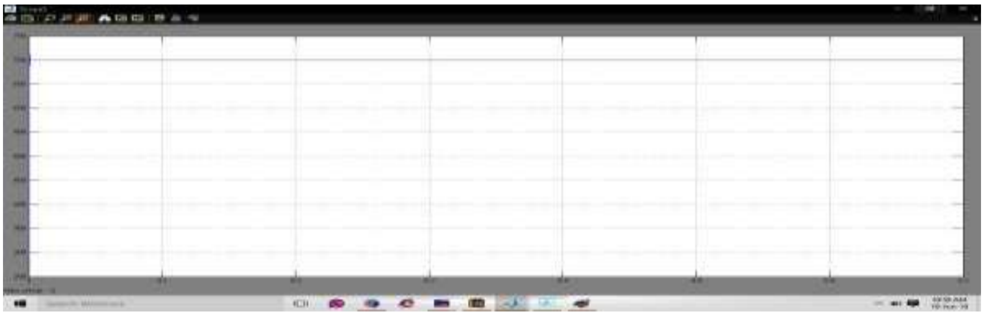


(a) PCC voltages (*vs*)

Figure 7 depicts the PV-UPQC-performance S's as irradiation changes. Phase 'a' load currents (iL), series voltages (vSE), PV array power (Ppv), and a power angle () are all indicated, as are voltages on the PCC, voltages on the load, and voltages on the DC bus. There are also grid currents (is), voltages on the load, and voltages on the DC bus. The sun irradiation is changed from 1000 W/m2 to 500 W/m2 between 0.95 s and 1 s. Figure 5.4 shows that the power angle and series VSC voltages increase as the PV power increases. For this reason, grid current draw is reduced because of the PV array power supplying part of the load's genuine power need. Because of this, the load angle and series VSC voltage are greater when the PV array power is lower than in the situation where the same reactive power is compensated.

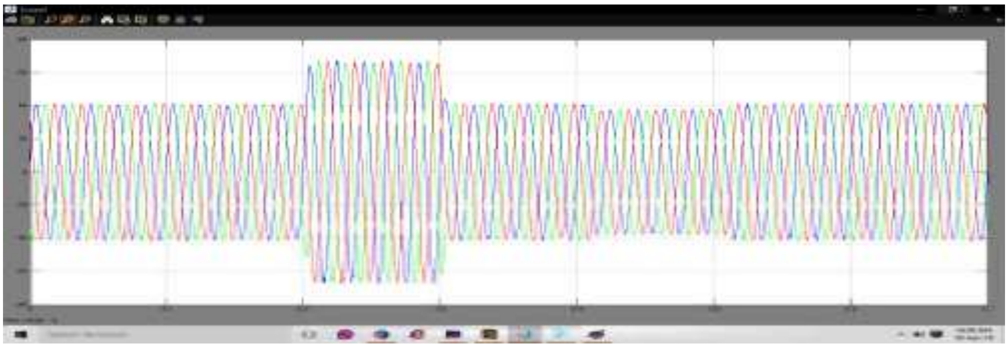


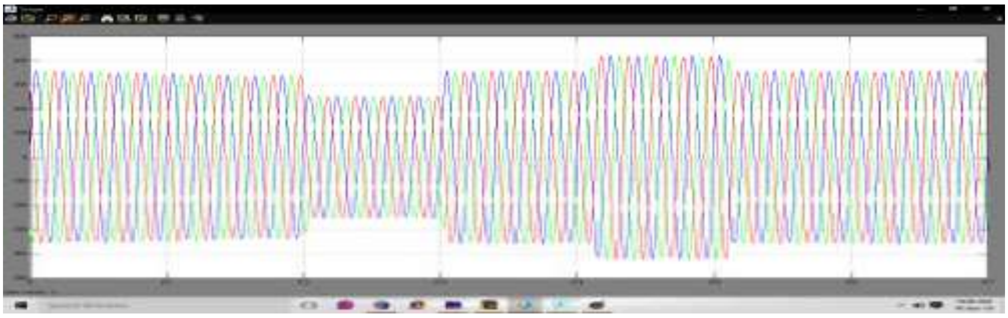
CASE-C:PV-UPQC-S PERFORMANCE DURING PCC VOLTAGE DISTURBANCES



(a) (a) PCC voltage load voltages (*vL*)

(a) DC-bus voltage (*Vdc*)





(h) series VSC voltages (vSE)

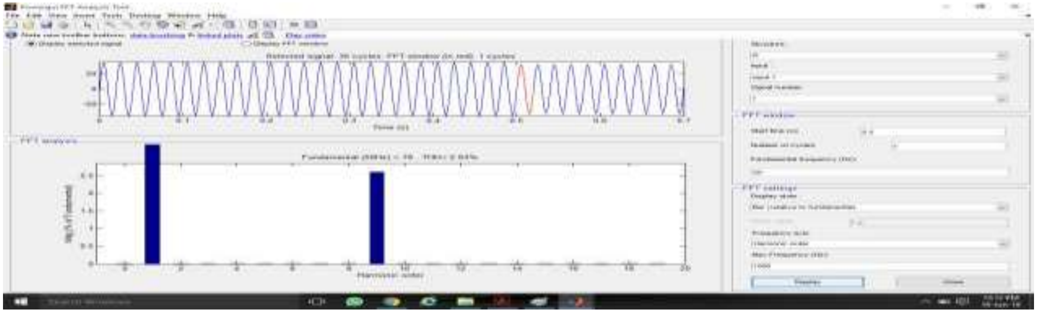


Fig:8. PV-UPQC-S Performance during PCC Voltage Fluctuations

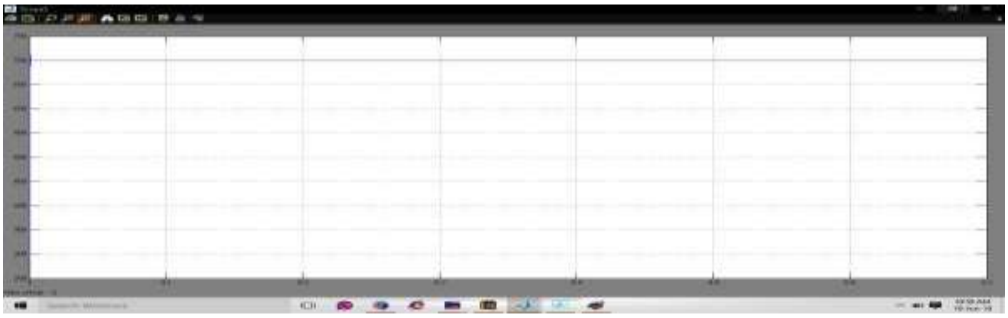
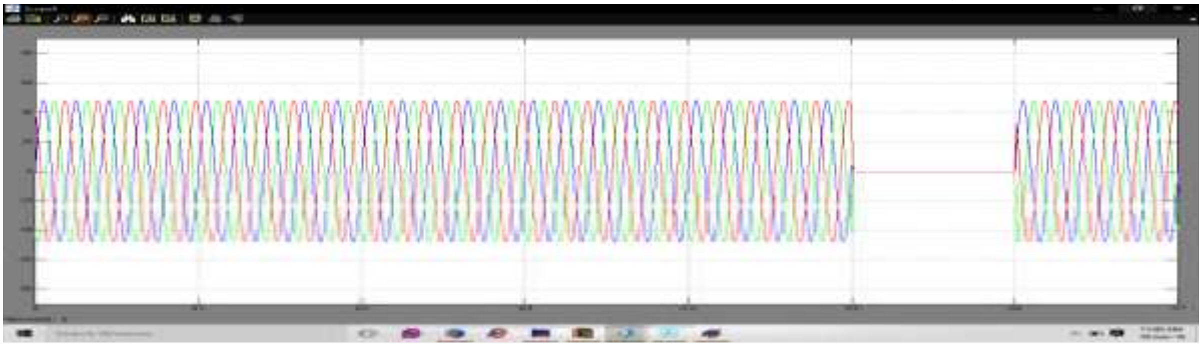
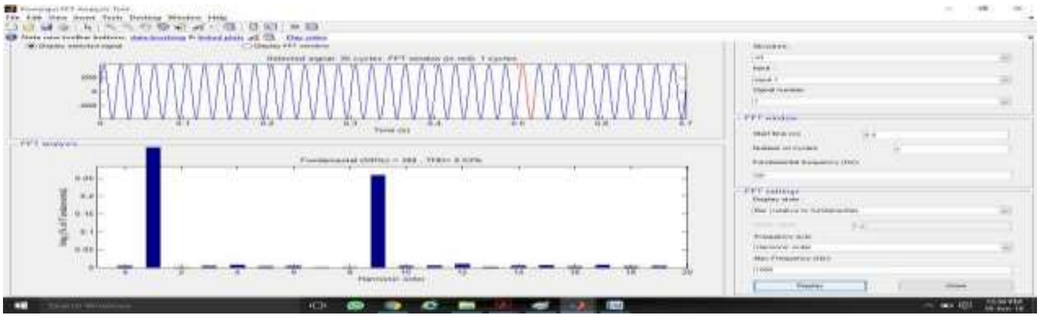


Figure 8 depicts the PV-UPQC-S response to a PCC voltage disturbance. a constant 1000 W/m2 of solar irradiation (G) is used. Among the many signals shown are: the phase 'a' voltage of PCC (vs), the loads' voltages (vL), the DC-bus voltage (Vdc), grid currents (is), the loads' current (iL), the shunt VSC current (iSH), the PV array power (Ppv), the power angle (), and series VSC voltages (vSE). The only phase signals are presented in certain cases for clarity's sake. A 0.3-pu voltage drop occurs at 0.65 seconds while a 0.3-pu voltage rise occurs at 0.75 seconds. Both have harmonic distortion. Despite the PCC voltage aberrations, the load voltage may be shown to be sinusoidal and reference value. The series VSC continues to share a portion of the load's reactive power under normal circumstances, as shown by and vSE. Series VSC adjusts exclusively for swell and does not share reactive power during swell circumstances, as evidenced by the zero when voltage rises. It takes two



cycles for the series VSC to compute power angles after the PCC voltage swell. Due to the use of low pass filters in the computation of PL and QL, this has occurred.Fig:9. load current

load voltage



The simulation results are presented to show the effectiveness of the PV-UPQC-S and here obtained an acceptable THD for source current and kept load voltage at its nominal value.

V. CONCLUSION

The dynamic performance of a PV-UPQC-S based on modified p-q theory has been thoroughly examined. The FFPS component of distorted PCC voltages was extracted using a GCDSC block and then used to regulate PV-UPQC-S utilising p-q theory. Modified P-Q theory allows PV-UPQCS to operate in distorted PCC voltages. Sharing some of the load's reactive power with the series VSC results in increased usage of the series VSC and less stress on its shunt counterpart. A voltage sag or swell scenario is used to demonstrate PV-UPQC-S' dynamic performance in situations of abrupt changes in irradiance and variations in PCC voltage. Multiple disturbances, such as irradiation variation and PCC voltage fluctuations, may be handled by the suggested approach.
simultaneously. The PVUPQC- S system combines concept of clean energy generation along with power quality improvement thus increasing its utility.

REFERENCES

[1] The electrical power quality and the constraints encountered by power assembly applications in the petrochemical sector, IEEE Trans. Ind. Appl., vol. 52, no. 5, Sept. 2016, pp. 4495–4502, L. F De Oliveira Costa and J M de Carvalho Filho [1].

[2] IEEE Transactions on Industrial Applications, vol. 52, no. 1, January 2016, pp. 360–368, A. Banerji, S K Biswas, and B Singh, "Enhancing quality of electricity to sensitive loads using microgrid," Jan 2016.

[3] (1) IEEE Transactions on Smart Grid, vol. 8, no. 1, january 2017, pages 418–428, Hafezi, et al: "Power quality conditioning in LV distribution networks: Results by field demonstration," Hafezi et al: "Power quality conditioning in LV distribution networks: Results by field demonstration."

[4] There are several ways to regulate a three-phase, single-stage grid-tied solar PV ECS, but one of the most common is to use a pll-less fast ctf control approach.

[5] Better control for a solar energy system: Using improved enhanced phase-locked loop based control under variable solar intensity, IEEE Industry Applications Magazine, vol. 23, no. 2, March 2017, pp. 24–36, by S. Kumar, A. K. Verma, I. Hussain, B. Singh, and C. Jain, IEEE Industry Applications Magazine, March 2017.

[6] In IEEE Transactions on Sustainable Energy, vol. 6, no. 2, pp. 400–410, April 2015, A. M. Rauf and V. Khadkikar describe an integrated photovoltaic and dynamic voltage restorer system configuration.

[7] V. Khadkikar and A. Chandra, "A new structure for three-phase fourwire

distribution system adopting UPQC," IEEE Trans. Ind. Appl., 45(5), 1897–1902, September 2009.

[8] A complete review of the use of UPQC to improve electric power quality was published in IEEE Trans. Power Electron. in May 2012, volume 27, number 5.

[9] It is important to note that the IEEE Trans. Power Dev., Vol. 29, Nos. 3 and 4 (pp. 1490–1498, June 2014) have published a paper on "optimal size of the upqc considering va loading and maximum utilisation of power-electronic converters."

[10] For example, [10] V. Khadkikar and A. Chandra, "UPQC-S: A new concept of simultaneous voltage and load reactive power compensations using UPQC-S," IEEE Trans. Power Electron., volume 26, issue 9, pages 2414–2425 in September 2011.