IOSR Journal of Engineering (IOSRJEN) **www.iosrjen.org**
ISSN (e): 2250-3021, ISSN (p): 2278-8719
Vol. 09, Issue 12, December. 2019, Series -I, PP 16-23

Solar Integrated UPQC to Connected to the Distribution System for Power Quality improvement

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Received 26 November 2019; Accepted 11 December 2019

Abstract: Distributed Generation (DG) frameworks in view of RES have contributed to discover new present day answers for arranging control of traditional power frameworks. In the paper solar fed grid-connected UPQC system with combined operation as a power quality conditioner is presented. The performance analysis of the proposed PV-UPQC system is presented understatic and dynamic operation to improve power quality by reducing harmonics of the system. The PV system designed is dual-stage type having DC-DC boost converter and DC/AC inverter.

I. INTRODUCTION

As a worldwide answer for beat the rising demand of power, renewable energy is turning into a promising alternative. The renewable energy like solar, wind, fuel cell etc. has increased penetration in the conventional power system. Among the all type solar is the most acceptable since it has most developed and cheap technology in terms of harnessing energy to convert into useful work and also accessibility of sun energy around the earth and the advancements in sunlight based innovation had made a sun based energy system a dependable wellspring of vitality today. One more preferred standpoint that sunlight based energy has is that, it is a green and clean type of vitality that implies its carbon emanation is low as contrast with conventional source of power creation like thermal and so on. There carbon outflow is high and they contaminate nature. There are number of overwhelming issues for the most part identified with control quality like power factor, responsive power quality, voltage flicker and harmonics in a PV framework associated with grid [2]. The general execution of the aggregate framework gets influenced and it turns into a genuine worry for the end clients. All in all, it diminishes the effectiveness and life of the gear and machines. The scientists constantly attempting to manage every one of these issues and to some degree a fruitful arrangement by planning appropriate control technique for inverter interfacing PV system to the grid, can be accomplished.

Renewable energy has its new ways to contribute to the utility system. It not only supplies to the local load in conjunction with the grid connected operation but may also assist in operating as a compensating device to improve the power quality (PQ) of the system.Specifically, by methods for photovoltaic (PV) cells, PV panels have been appropriately intended to deliver vitality by changing over daylight into power. Typically, framework associated PV frameworks can be conveyed by methods for single-stage (S-S) or dual-stage (D-S) control transformation [1]. S-S PV frameworks are typically made out of direct coupled grid tied inverter (DC/AC conditioning converter) [2]. For this situation, the PV exhibit is specifically associated with the dc-transport of the matrix tied inverter. Then again, in D-S PV systems, an extra dc/dc converter is put between the PV panel and the inverter [3]. In this design, the maximum power point tracking (MPPT) is performed by the dc/dc converter [4]. Considering SS-PV frameworks, the errand to play out the MPPT is expected by the network tied inverter, joined with the upside of accomplishing more productivity when contrasted with DS-PV frameworks [5].

The present day distributed and regulated structure of power system is not only consumer favorable but also has very complex control structure due to which quality of power is threatened.

Among all power quality related issues the most frequently occurring is voltage quality problems like voltage sags/swells,interruption, flicker and eventually instability in the grid [1].The side effects of voltage quality problems are frequentfalse tripping of power electronic systems,false triggering and malfunctioning ofprotective devices etc [2]–[4].One more threatto PQ is non-linear load which mainly alters the current quality. These nonlinear loads inject harmonics into distributionsystem. These harmonics in current lead to distortion ofpoint of coupling (PCC) voltage especially in weak grids apartfrom causing losses in distribution cables and transformers.

Classes of devices are emerging as a profitable solution to all type of PQ issues is Custom Power Devices such as distribution static compensator(DSTATCOM), dynamic voltage restorer (DVR) andunified power quality conditioner (UPQC) are used to mitigate PQ problems.In this paper PV based UPQC is designed to mitigate PQ issues generated by renewable energy integration and non-linear loading.

II. POWER ELECTRONIC CONVERTERS TO SOLVE PQ ISSUES

Transition towards greener energy sources has accelerated with the increased penetration of grid tied solar system. The increasing number of renewable energy sources and distributed generators requires new strategies for the operation and management of the electricity grid in order to maintain or even to improve the power-supply reliability and quality. Keeping in view of the aforesaid some of the possible solutions have been proposed by researchers.

The PECs are an important part in integration of renewable energy sources into the electrical grid, and it is widely used and rapidly expanding as these applications become more integrated with the grid- based systems. Due to two factors, power electronics has resulted in fast technological evolutions, during the last few years; the first one is the development of fast semiconductor switches that are capable of switching quickly and handling high powers. The second factor is the introduction of real- time computer controllers that can implement advanced and complex control algorithms. These factors together have led to the development of cost- effective and grid-friendly converters and increased the stability of the system.

These converters not only integrate the RES into the grid but they are designed so to handle PQ issues of the system. Some such converters reported in literature are;

- OLTC (on load tap changing transformer) [6];Capable of controlling Reactive power, voltage flicker and voltage stability.
- Capacitor & Reactor Bank [7], Can control Reactive and active power, voltage flicker, voltage stability oscillation damping, harmonics.
- APF (Active power filter) [8], can control Reactive and active power, voltage flicker and voltage stability.
- DVR (dynamic voltage restorer) [9], Can control active power, voltage flicker, voltage stability oscillation damping.
- SDBR [10] (series dynamic series resistor), Can control active power and oscillation damping.
- STATCOM [11] (static compensator)Can control Reactive and active power, voltage flicker, voltage stability oscillation damping, power flow.
- DSTATCOM (Distributed Static compensator) [12], DSTATCOM are employed to compensate poor load power factors for low and medium power applications.
- SVC (static VAR compensator) [13], Can control Reactive and active power, voltage flicker, voltage stability.
- TCSC (Thyristors controlled series capacitor) [14]. Can control Reactive power, voltage flicker, voltage stability oscillation damping, power flow.
- UPQC (unified power quality conditioner) [15]. Can control Reactive and active power, voltage flicker, voltage stability harmonics, power flow.

III. PV FED UNIFIED POWER QUALITY CONDITIONER (PV-UPQC)

Universal power quality conditioners (UPQCs) permit the moderation of voltage and current unsettling influences that could influence delicate electrical burdens while remunerating the heap responsive power. It goes for the mix of arrangement dynamic and shunt-dynamic power channels. The fundamental reason for an UPQC is to make up for voltage unevenness, responsive power, negative grouping current and sounds.

Integral parts of Unified power quality conditioner are Power Source, Shunt Active Filer and Load.The proposed UPQC system is assign dual compensating strategy. The dual compensating strategy connected to UPQC varies from the conventional technique because of the parallel converter being controlled to work as a sinusoidal voltage source giving adjusted and directed sinusoidal voltages to the heap. As the parallel converter acts as a sinusoidal voltage source, a low impedance way is accomplished. For this situation, the sinusoidal current through the parallel converter is permitted. Then again, the series converter is controlled to work as a sinusoidal current source, depleting adjusted sinusoidal voltage from the utility grid. In the proposed work the above mentioned UPQC controller is fed by solar system. The system designed serves two purpose as shown in figure-1. One purpose isit integrate the solar with the grid and another it regulates the PQ related issues of the grid to which PV is connected.

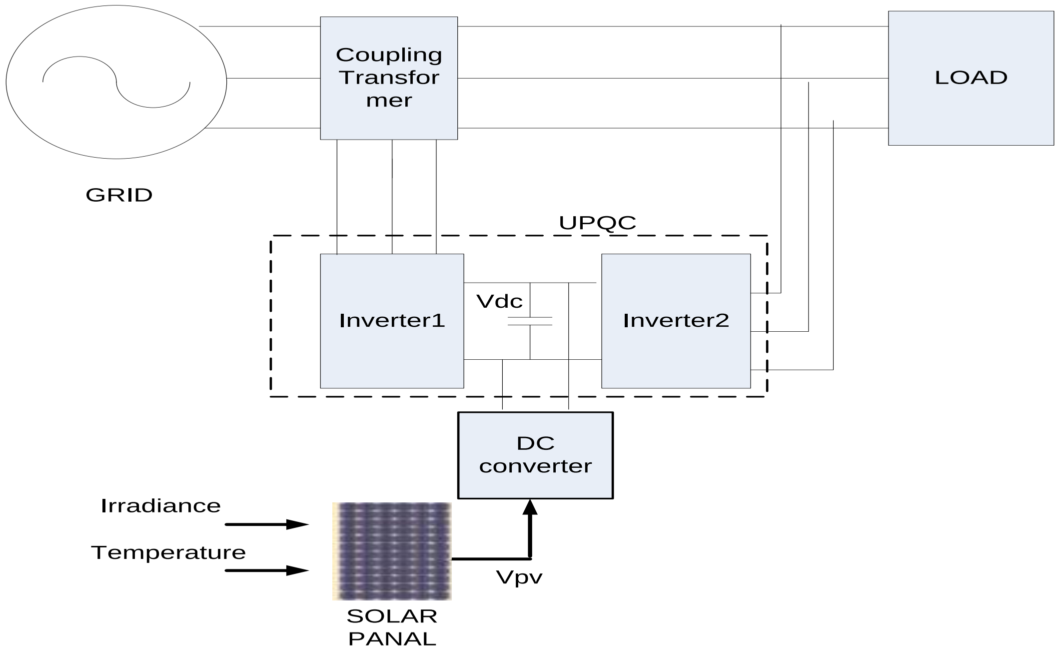

Figure-1Proposed PV-UPQC system

IV. SIMULATION AND RESULT DISCUSSION

Although PV systems are emerging as power solution to meet the increased demand of electricity, but the reliability and robustness of the PV panel is always questionable. A simulation model for PV based UPQC converter is designed to stabilize the output of solar system at various modes of operation in Matlab simulink. A dual compensating strategy is adopted to operate the PV-UPQC system, where the parallel converter is controlled to act as a sinusoidal voltage source, while the series converter is controlled to operate as a sinusoidal current source. The DC/AC converter is controlled through PLL and PI in order to suppress load harmonic currents and compensating reactive power. Furthermore, regulated, balanced, and harmonic-free output voltages are provided to the load. The designed system is analysed for the following modes of operation;

1. Steady State Operation of PV-UPQC
2. Performance of PV-UPQC under Varying Irradiation
3. Performance of PV-UPQC under Grid Voltage Fluctuations

The parameter selection two model the solar system and UPQC is presented in table 1 and 2.

Table-1 Component and rating for solar system.

COMPONENTS	RATINGS
Solar panel	170 V, 6 KW
DC-DC boost converter	520 V
Three phase DC/AC inverter	600 V

Table-2 Component and rating used in the UPQC topology.

COMPONENTS	RATINGS
Nominal utility voltages (rms) V	415
Nominal Frequency ω	50Hz
Inverter inductance L	45mH
Filter Capacitance C	60e-6 F
Filter Inductance L_f	10.45e-3 H
Non-linear Load Three phase load through rectifier	R=10 ohms, C=1mF

- **Steady State Operation of PV-UPQC**

In this operating mode the system is analysed under three phase balanced non-linear load connected through the three phase rectifier. The solar irradiation is kept constant at 1000 W/m^2. Figure 2 presents output waveform source side for this mode and figure to at load side.

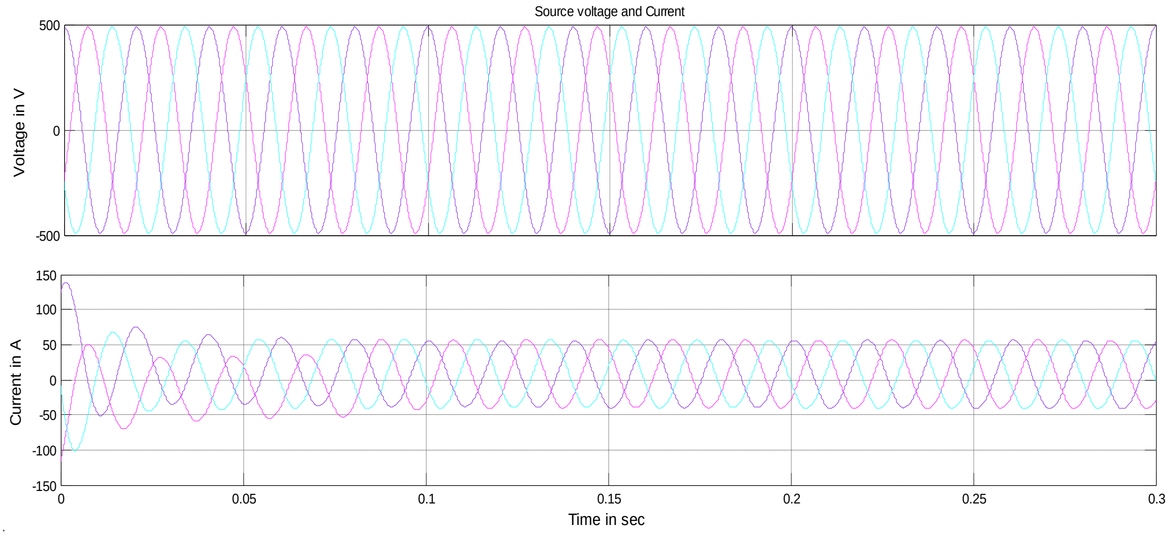

Figure 2 Output voltage and current waveform source side doe static operation.

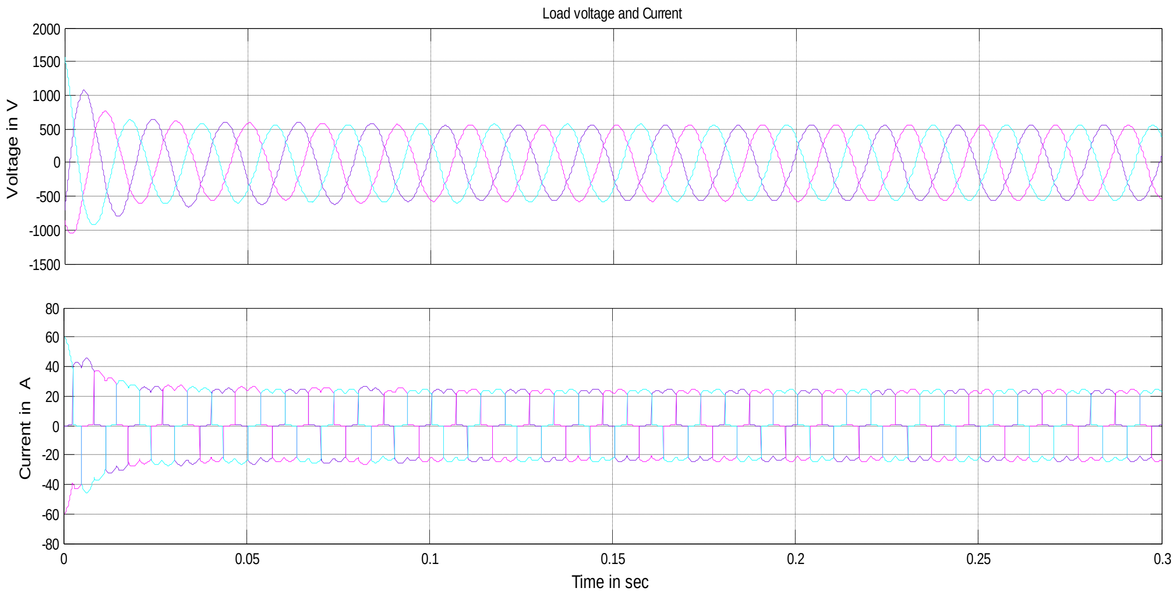

Figure 3 Output voltage and current waveform load side for static operation.

- **Performance of PV-UPQC under Varying Irradiation**

In this condition the solar irradiation across the PV panel is varied from 0 to 1000 W/m^2. Figure 4 and 5 presents the output voltage and current waveforms for this mode of operation.

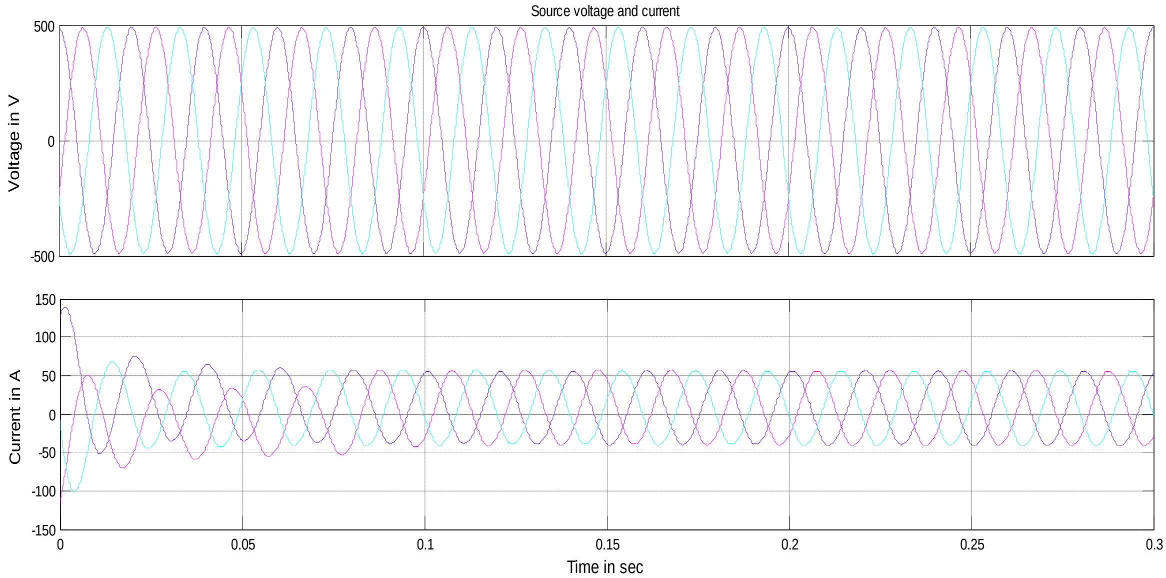

Figure 4 Output voltage and current waveform source side for variable solar irradiation operation.

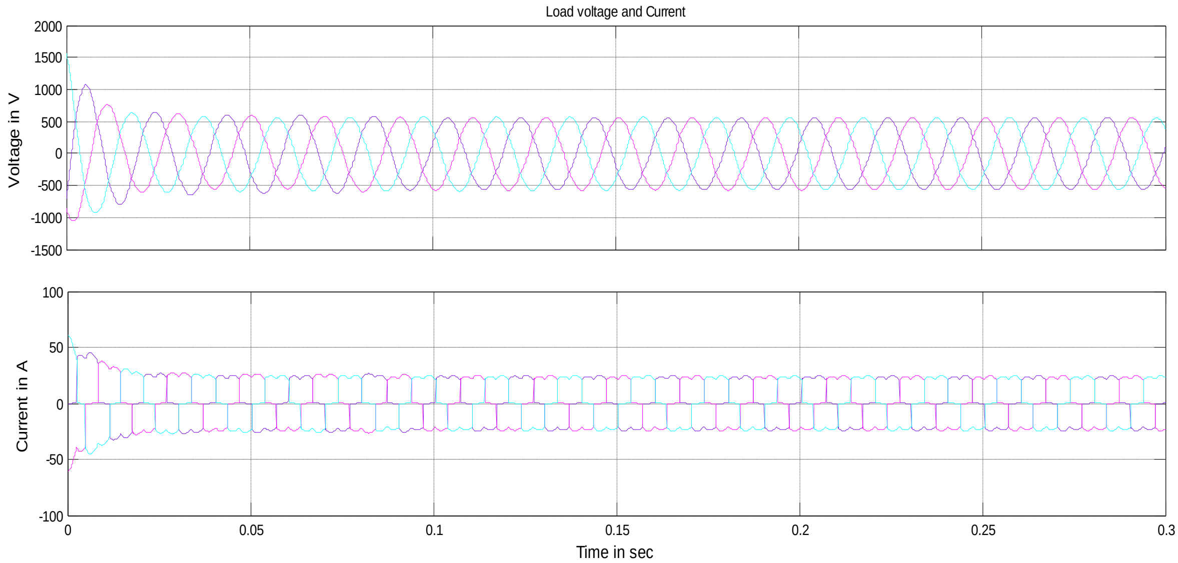

Figure 5 Output voltage and current waveform load side for variable solar irradiation operation.

- **Performance of PV-UPQC under Grid Voltage Fluctuations**

The dynamic performance of PV-UPQC under conditionsof grid sags is shown in Figure 6 and 7. The irradiation (G) isat 1000 W/m^2.

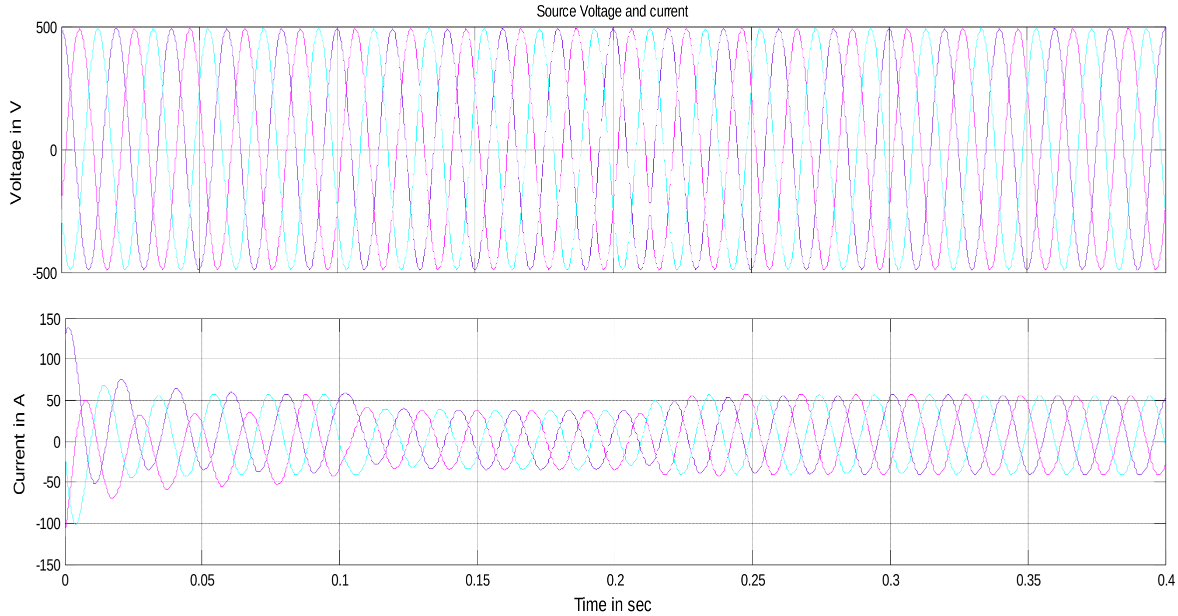

Figure 6 Output voltage and current waveform source side for voltage sag operation.

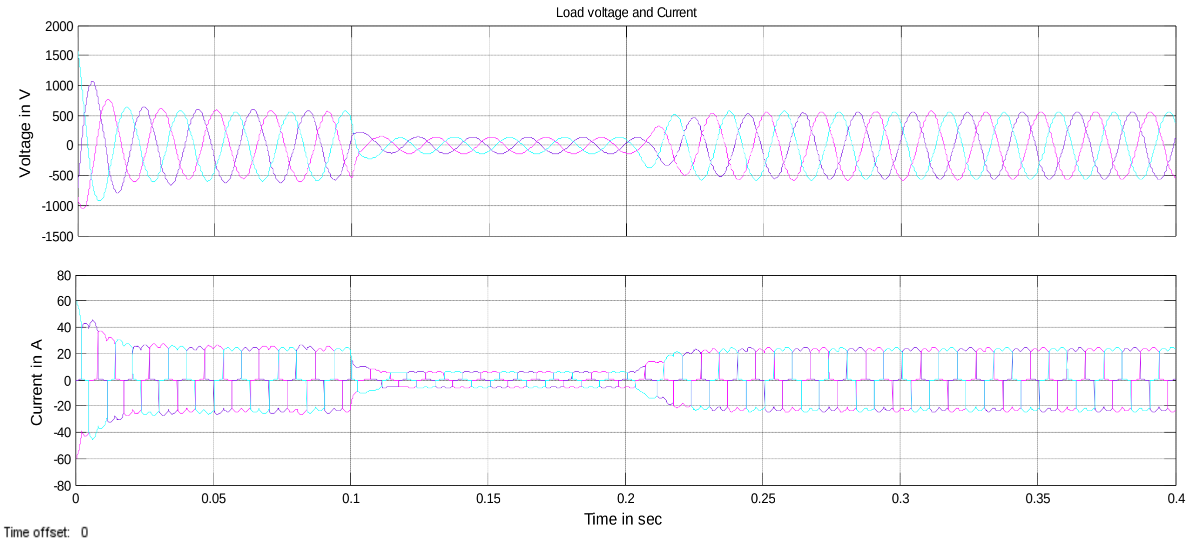

Figure 7 Output voltage and current waveform load side for voltage sag operation.

The THD analysis at point of common coupling (PCC) voltage, load voltage, load current and grid currentare shown in Figure 8 and 9. It is observed thatthe load current THD is 25.35% and the grid current THDis 1.23%. The PCC voltage THD and load voltage THD arealso limited to below 5%, thus the proposed system meets the grid code requirement.

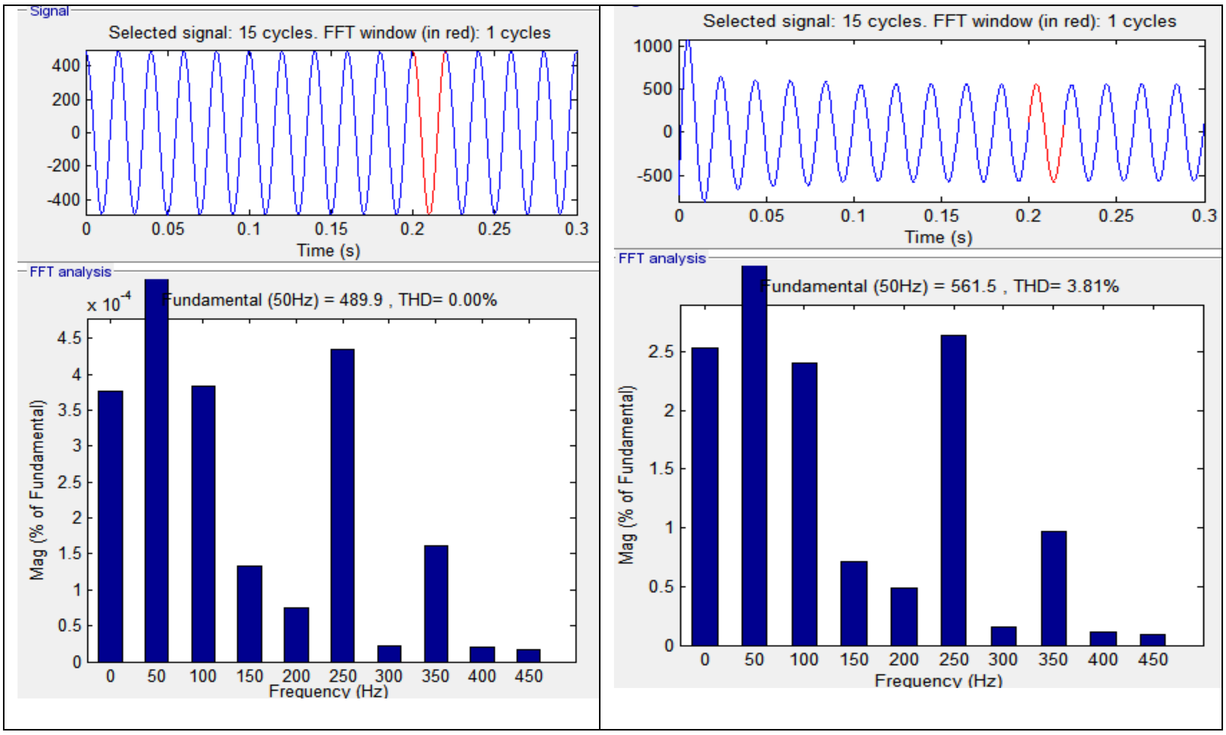

Figure 8 Comparative THD analysis of source voltage and load voltage

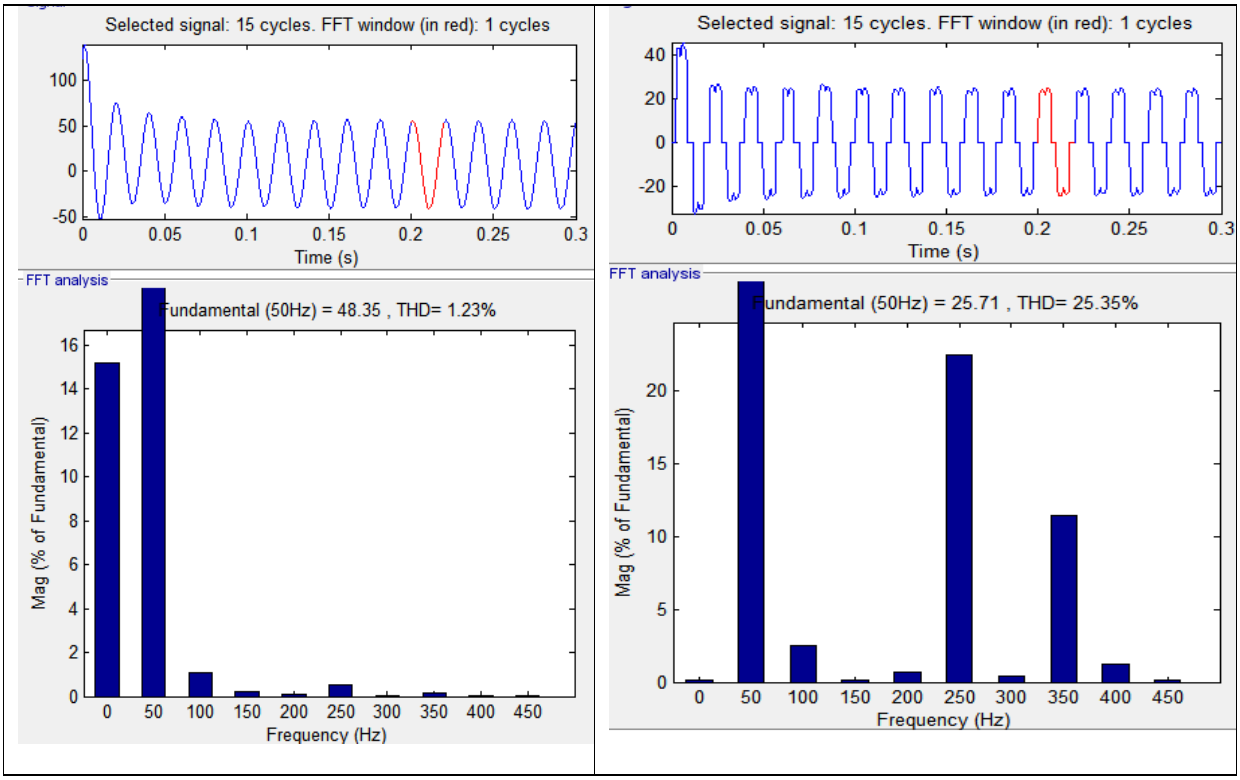

Figure 9 Comparative THD analysis of source current and load current

V. CONCLUSION

The fundamental of UPQC is that it prevents the abnormalities of load side to propagate to the source side hence safeguarding the other voltage sensitive equipment against the harmonic and voltage related PQ issues. In the proposed work the PV-UPQC system not only mitigate the load current and load voltage harmonics but also it integrates the solar to the grid hence improving the stability of the system. The system is found to be stable under variation of irradiation from 1000 $W/m2$ to 600 $W/m2$. It can be seen that PV-UPQC is a good solution for modern distribution system by integrating distributed generation with power quality improvement.

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