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Mitigation of Power Quality Problems Using 3-Phase PV Integrated UPQC

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ABSTRACT: In this project, extending the conventional upqc to solar PV (photovoltaic) integrated UPQC are presenting. The upqc consists of a shunt and series connected voltage compensators connected back to back with common DC-link. The modified upqc to adding non-conventional sources like solar and wind. It is added to upqc additional advantages that is delivering active power to the load.it decreasing overloading problem on source or grid side. The upqc has advantages of improving power quality problem. Series compensator of upqc works like DVR (dynamic voltage restorer) compensates for the grid side power quality problems such as grid voltage sags/swells. Shunt compensator of upqc work like DSTATCOM and compensate harmonics due to nonlinear load. Solar PV array by operating it at its maximum power point (MPP). Selected capacity of pv array is around 50% of load capacity. The dynamic performance of the proposed system is simulated in Mat lab-Simulink under a nonlinear load consisting of a bridge rectifier..

KEYWORDS:upqc; dstatcom; dc-link; pv array;

I.INTRODUCTION

The use of power electronic devices and modern electrical devices introduces harmonics in the supply system which creates a problem in the quality of power delivered. Good Power Quality is very much important for our day to day use of appliances in both industrial and domestic sectors. Researchers have tried and implemented many useful technology for removing all the voltage and current related harmonic occurrence problems which in turn improves the quality of power delivered to the power system. The prime focus of this is the implementation of control strategies like SRF theory and instantaneous power (p-q) for the operation of Unified Power Quality Conditioner (UPQC) which is one of the recent technology that includes both series and shunt active power filter operating at the same time and thereby improves all the current and voltage related problem like voltage sag/swell, flicker, etc. location of the shunt compensator and control methodology of the series compensator Based on the location of shunt compensator, there are two classes of UPQCs namely, UPQC-L (UPQC left shunt) and UPQC-R (UPQC right shunt). In UPQC-L, the shunt compensator is at the grid side and in UPQC-R, the shunt compensator is at the load side. Another classification of UPQC is based on the phase of voltage injection angle namely UPQCQ, UPQC-P, UPQC-S. In UPQC-Q, the series compensator injects voltage in quadrature with the grid current; whereas in UPQC-P, the series compensator of UPQC injects voltage in same phase as that of the grid current. In UPQC-S, the voltage is injected at a phase with respect to grid current such that it results in both reactive and active power injection.

II. SYSTEM CONFIGURATION AND DESIGN

The structure of the UPQC is shown in Fig.1. The UPQC is designed for a three-phase system. The generating gate pluses to the series and shunt inverters through controllers design by PI and P-Q theory technic. The modified UPQC is shown in fig-2. The PVarray chosen that it can deliver active power to the load through shunt compensator through point of coupling. The load used is a nonlinear load consisting of a bridge rectifier with a voltage fed load

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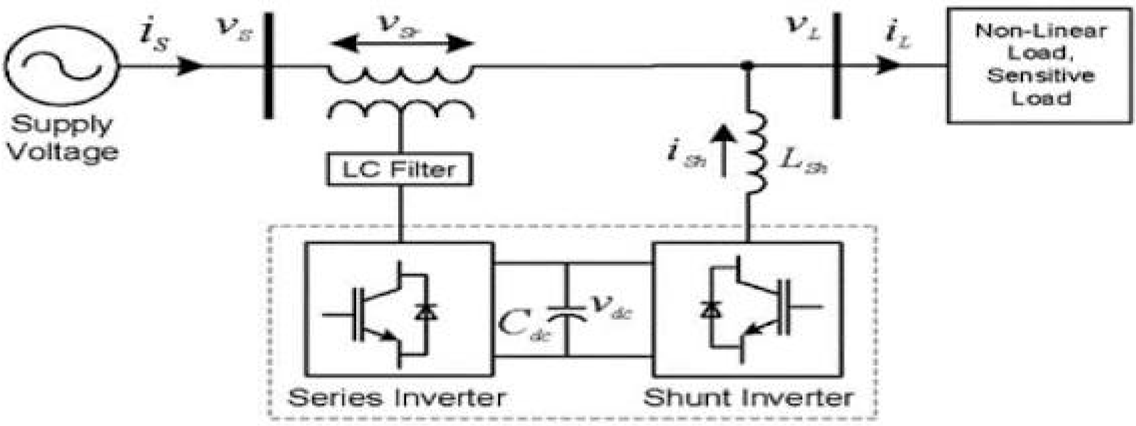

Fig1 single line diagram of UPQC

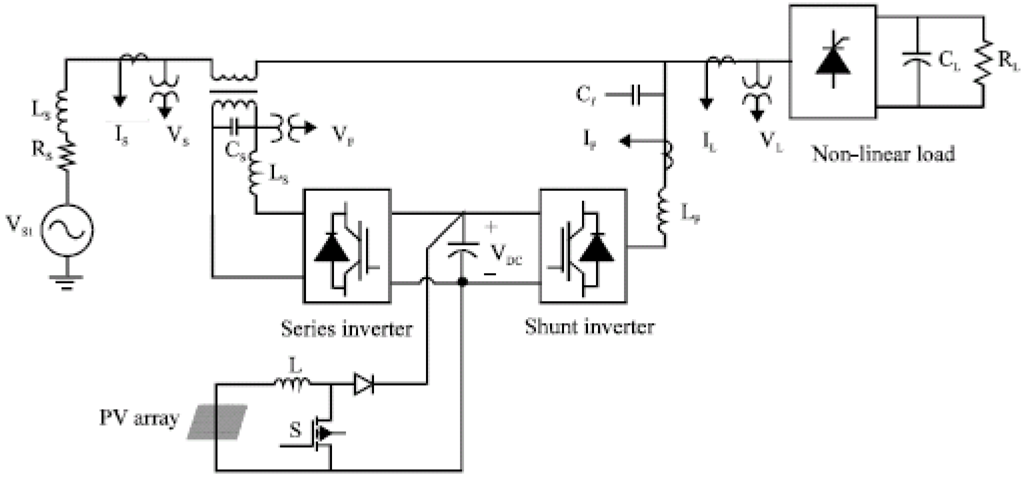

Fig2 single diagram of PV-UPQC

III.DESIGN OF PV-UPQC

The design procedure for PV-UPQC begins with the proper selecting of PV array, DC-link capacitor, DC-Link voltage level etc. The selected PV array can able to deliver at least 50% of load capacity. The shunt compensator rating chosen that exactly same to the PVarray capacity to need to deliver active power to the load. The specifications of solar PV module and PVarray given in table-1.

1) PV Array

As the PV array is directly integrated to the DC-link of UPQC, the PV array is sized such that the MPP voltage is same as desired DC-link voltage .PVarray details and characteristics for different irradiance shown in fig.3 shown andLoad selection is combination of uncontrolled bridge rectifier with RL load(R=10ohm L=5mh)and combine 1000w active, 600var reactive power,

parameter	Value
Maximum Power (P)	6820.8 wats
Open Circuit Voltage (Voc)	290.4
Short Circuit Current (Isc)	31.36
Voltage at Maximum Power Point(Vmmp)	232
Current at Maximum Power Point(Immp)	29.4
Parallel strings	4
Series Modules per string	8

TABLE:1 PV ARRAY DETAILS

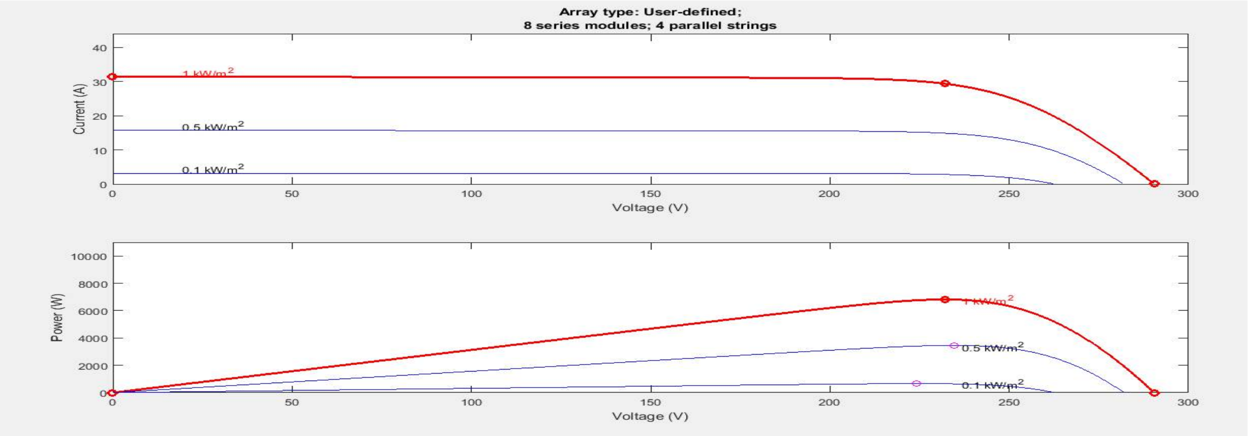

FIG-3 PV ARRAY OUTPUT POWER FOR DIFFERENT IRRADIANCE CONDITIONS

- **Vdc link voltage** chosen from Vdc = $\frac{2\sqrt{2}\,VL}{\sqrt{3}\,m}$ ...1
  Where VL is line voltage, m is modulation index chosen 1.
- **DC-Bus Capacitor Rating**:- The DC-link capacitor is sized based upon power requirement as well as DC-bus voltage level

  $$Cdc = \frac{3.k.a.Vph.Isha.t}{0.5\times(Vdc^2 - Vdc1^2)} \quad ...2$$

  where Vdc is the average DC-bus voltage, $Vdc1$ is the lowest required value of DC-bus voltage,a is the overloading factor, Vp□ is per-phase voltage, t is the minimum time required for attaining steady value after a disturbance, Is□ is per-phase current of shunt compensator, k factor considers variation in energy during dynamics.
- **Interfacing Inductor for Shunt Compensator:**depends upon the ripple current, the switching frequency and DC-link voltage

  $$Lf = \frac{\sqrt{3}\times m\times Vdc}{12.a.Fsh.Icr} \quad ...3$$

  where m is depth of modulation, a is pu value of maximum overload, fs□ is the switching frequency , Icr,pp is the inductor ripple current which is taken to be 20% of rms phase current of shunt compensator.

- **Interfacing Inductor of Series Compensator**:depends ripple current at swell condition, switching frequency and DC link voltage

  $$\text{Lf} = \frac{\sqrt{3}\times \text{mVdc}\times \text{Kse}}{12\times \text{a.Fse.Ir}} \quad ...4$$

IV. CONTROL OF PV-UPQC

The controller design for pv-upqc is based on p-q theory analysis This p-q approach is valid for operation under all conditions namely transient and steady state operation. This theory makes use of some famous transformation models defined like Clarkes Transformation. Here the voltage and current waveforms are sensed and then made to transform from a-b-c coordinates to $\alpha - \beta - 0$ coordinates. After this transformation, based on a certain set of equation we calculate active and reactive power and then eliminate the power components having harmonics in it by passing through a certain suitable low pass filter of suitable frequency.

The shunt compensator extracts power from the PV-array by using a maximum power point tracking (MPPT) algorithm. The series compensator protects the load from the grid side power quality problems such as sags/swells by injecting appropriate voltage in phase with grid voltage.To perform the load current compensation, the shunt compensator extracts the active fundamental component of the load current. Commonly reported techniques for signal extraction are instantaneous reactive power theory(IRP) , synchronous reference frame (SRF) theory instantaneous symmetrical component theory etc. For this work, the shunt compensator is controlled by extracting fundamental active component of load current using SRF technique. The control structure of shunt compensator is shown in Fig.2. The load current is converted to d-q-0 domain using the phase and frequency information obtained from PLL. The PLL input is grid voltage. The d-component of the load current is filtered using a low pass filter to extract DC component which represents the fundamental component in abc frame of reference. This component is added with the output of the DC link PI controller and then converted to abc domain which gives the reference grid currents. The reference grid currents are compared the sensed grid currents in a hysteresis current controller to generate the gating pulses for the shunt converter.

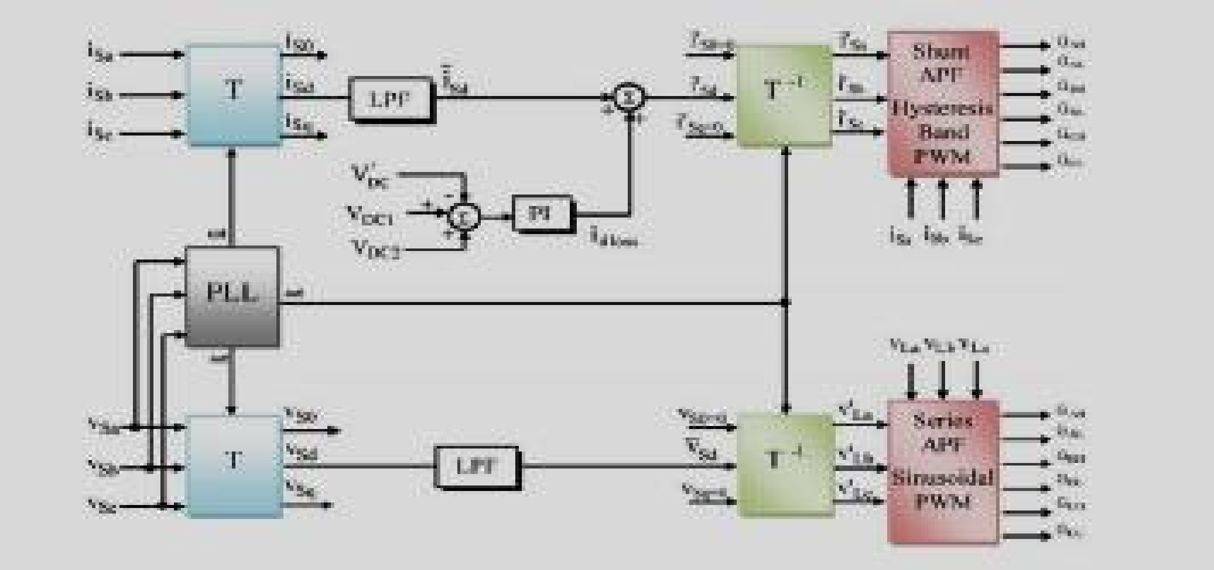

Fig.4 block diagram for series and shunt controllers

In series controller the fundamental component of grid voltage is extracted using a PLL which is used for generating the reference axis in dq-0 domain. The reference load voltage is generated using the phase and frequency information of grid voltage obtained using PLL. The grid voltages, load voltages and reference load voltages are converted into d-q-0 domain. The error between the reference load voltage and load voltage gives the series compensator voltage reference. The error between the load voltage and grid voltage gives actual voltage series compensator voltage. The difference between the reference and actual voltage of series compensator is passed through a PI controller for both d-axis and q-axis signals. The output of PI controllers are the reference signals for series compensator which are compared with actual voltages of series compensator and then passed through hysteresis voltage controller which generates the gating signals for the series compensator.

V. SIMULATION DIAGRAM AND RESULTS

The steady state operation of PV-UPQC is operated at irradiance 1000 w/m2. The PVarray can able to deliver 6kw of output .under 500w/m2 irradiance condition it can deliver nearly 2kw of output

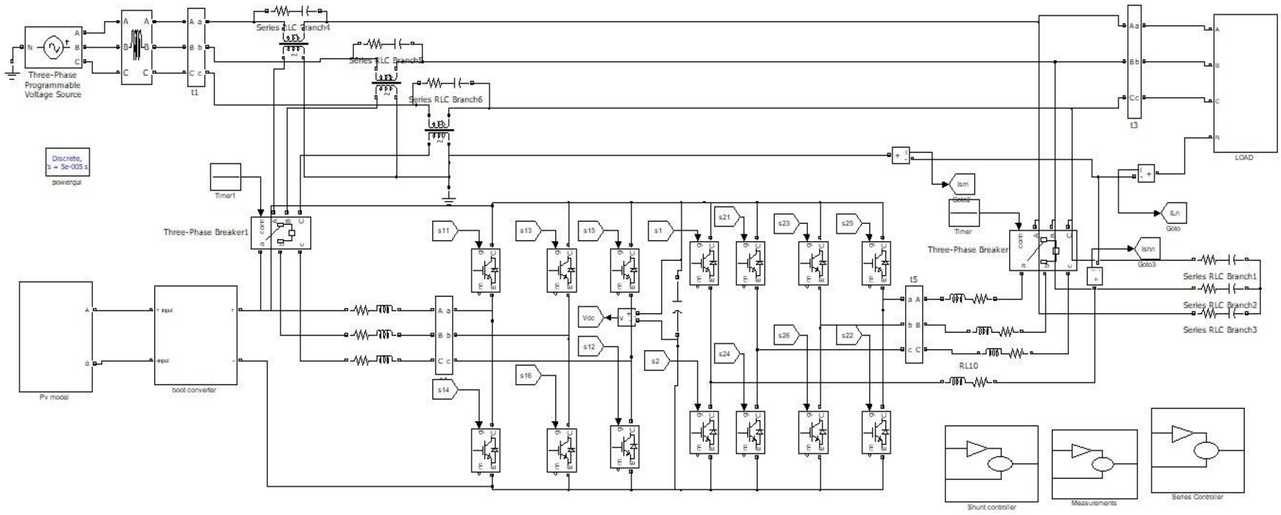

FIG.5 SIMULATION DIAGRAM PV-UPQC

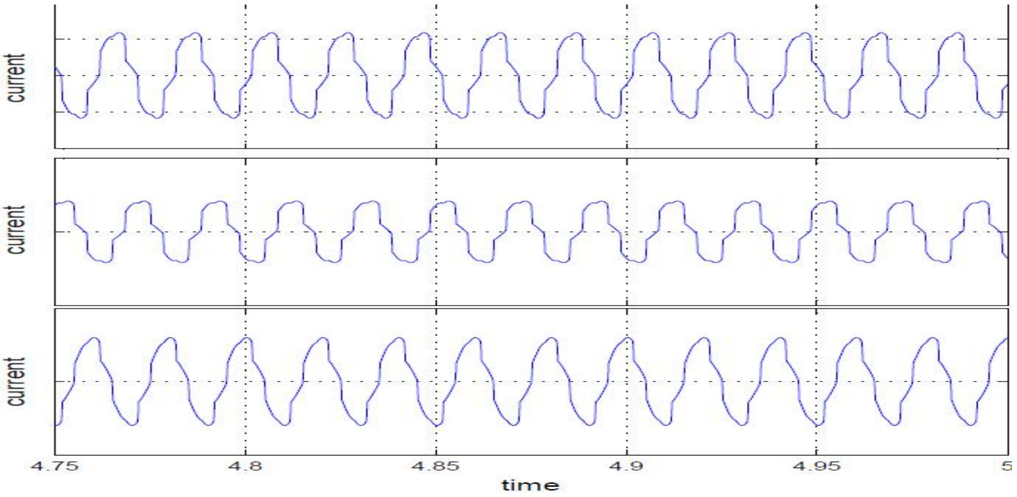

FIG-6 : LOAD CURRENT WAVE FORMS WITH HORMONICS

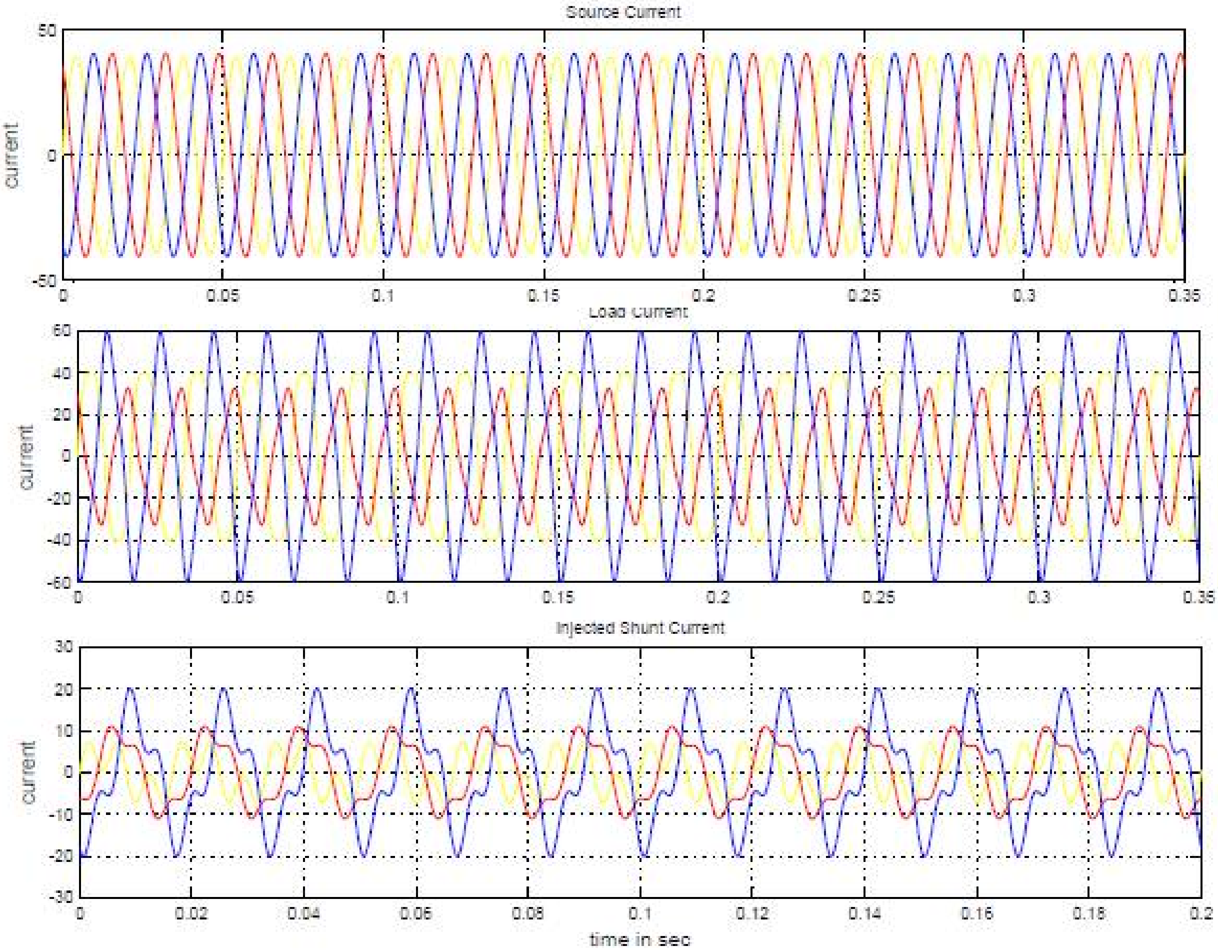

FIG.7 SOURCE,LOAD AND SHUNT CONTROLLER CURRENTS WITH UPQC

THD (%) COMPARISION OF SOURCE CURRENT	WITH OUT COMPENSATITION	WITH UPQC COMPENSATOR
PHASE R	17.80%	2.30%
PHASE Y	19.43%	2.28%
PHASE B	14.12%	2.32%

TABLE-1 THD COMPARISON OF SOURCE CURRENT

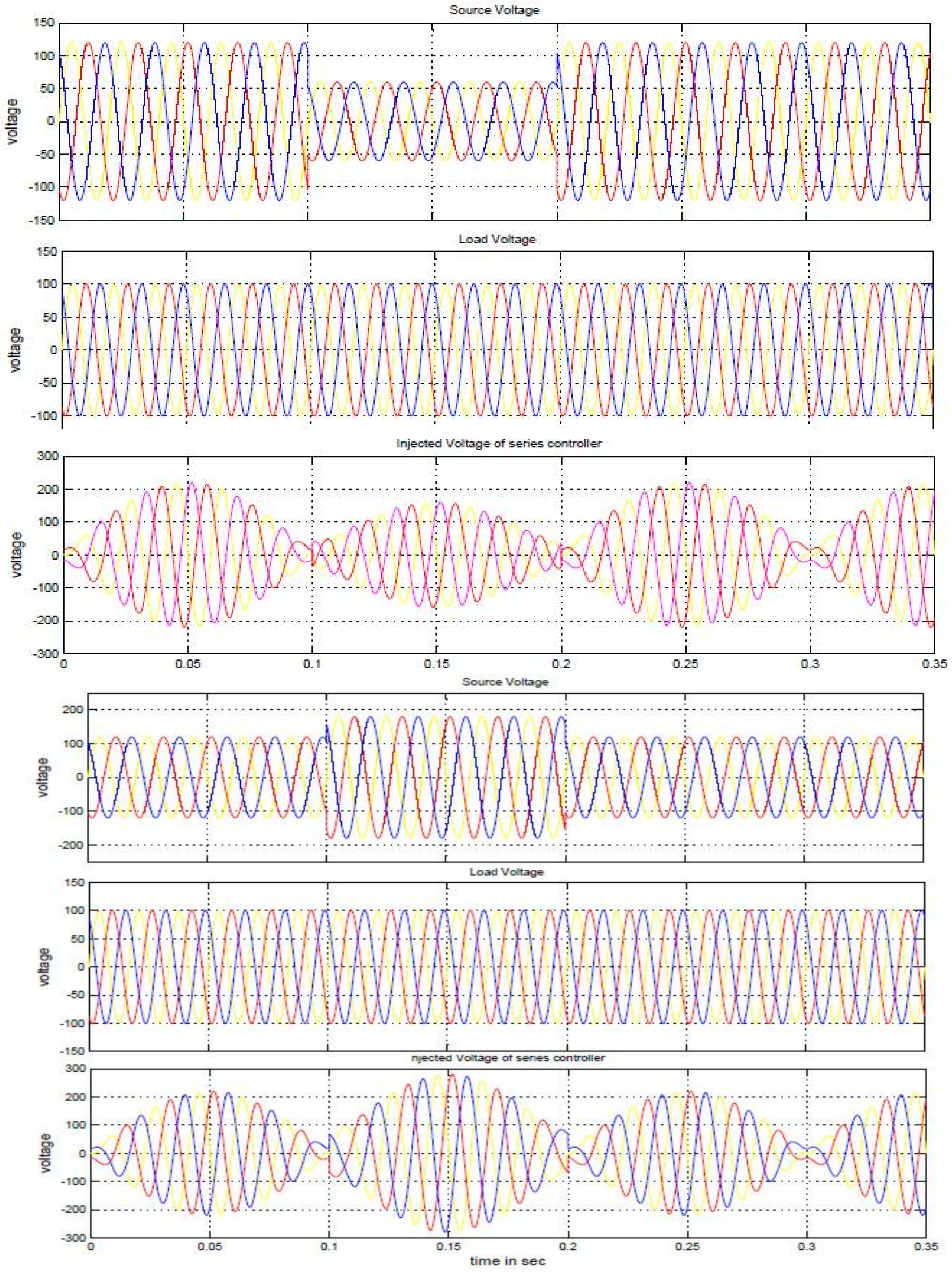

FIG-7 COMPENSATION OF SAG AND SWEL CONDITION OF GRID VOLTAGE

VI. CONCLUSION

The performance of three-phase PV-UPQC has been analysed under conditions of variable irradiation and grid voltage sags/swells. Such as $1000W/m2$ creating sag condition at different times of grid voltage.under low irradiance condition it can operate to compensate harmonics only. And THD values we calculated is within limits.it Can be seen that PV-UPQC is a good solution for modern integrating distributed generation with power quality improvement.

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