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POWER QUALITY ENHANCEMENT IN SOLAR POWER WITH GRID CONNECTED SYSTEM USING UPQC

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Abstract: This paper centers on alleviation of power quality (PQ) issues in a PV-incorporated framework by executing consistent Sinusoidal current control methodology (SCCM) based reproduction of UPQC (Unified Power Quality Conditioner) utilizing MATLAB in relationship with different burdens. The need to produce contamination free energy has set off the impact towards the use of sunlight-based energy interconnection with the matrix. Therefore, the Photovoltaic (PV) board interfaced with the network causes the force quality issues like a voltage sounds and voltage bending and so forth, Active force channels are the amazing asset for moderation of music. This work includes the utilization of single-stage Unified Power Quality Conditioner (UPQC) in light of a unit vector format control calculation. The recommended procedure guarantees sinusoidal amounts from source. Because of receptive force pay, the current and voltage repaid parts are in stage. As symphonious force is attracted because of non-direct loads, UPQC oversees in providing these consonant force parts confining something very similar to be drawn from the inventory. It oversees symphonious force of the heap just as zero succession power coming about to irregular characteristics in the framework. . It is suggested that the framework execution is completely checked by MATLAB reenactment with the reaction of burden varieties.

Index terms: UPQC, Solar energy, Filters, Sinusoidal current control strategy, PWM

I. INTRODUCTION

The requirement for power based environmentally friendly power sources that are interconnected to the conveyance network is becoming quickly. The principle inconvenience of environmentally friendly power is the brokenness of force age, which depends on the season [1–3]. To conquer these deficiencies, the quantity of environmentally friendly power assets is interconnected. Thinking about the pay standard and different control systems of the UPQC in the augmentation and execution of the UPQC is inspects taking care of a nonlinear burden that goes about as a wellspring of sounds. The fundamental square chart of UPQC is appeared in Fig. 1. Since non-direct loads have been utilized to add to the age of huge consonant substance in the matrix, they seem to contribute basically to the corruption of Power Quality (PQ) by changing the attributes of the sinusoidal basic voltage [4,5].

Along these lines, when the consonant flow communicates with the utility impedance, the subsequent symphonious mutilation in the voltage may influence the buyer's PQ at where the normal electrical framework is coupled to the Point of Common Coupling (PCC). An UPQC has produced as a choice to limit some PQ issues [6]. They have been utilized to dispose of or relieve the effect of symphonious flows brought about by non-direct loads on power frameworks. Consider a few

matrices of single-stage framework associated photovoltaic framework with UPQC utilizing various techniques to play out the accompanying purposes:

1) Injecting dynamic capacity to the framework;

2) Compensating of the heap responsive force; and

3) Suppressing of the heap symphonious flows.

Subsequently in this work present unit vector layout control calculation incorporates a Phase Locked Loop (PLL) instrument to improve the presentation against power quality issues. In this way, a reference sign of the UPQC is acquired by utilizing a technique dependent on a unit vector layout to help out the DC transport regulator. For this situation, the sythesis of remuneration current, pay voltage, responsive force and consonant current is regulator dependent on the calculation of

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unit vector format coordinating and hysteresis current control plot. The PV cells utilize different materials including semiconductors. Silicon is the most generally utilized material for manufacture of the PV cells. Various types of silicon are utilized, e.g., straightforward translucent, multi-glasslike and formless. Polycrystalline, slim thwarts, for example, copper indium diselenide (CuInSe2), cadmium telluride (CdTe), and gallium arsenide (GaAs) are further materials for the creation of the PV cells. To choose the force age by PV the evaluating of sunlight based radiation is huge one [6].

The leftover piece of this work is coordinated as: Chapter2: Explains the different Power quality control systems. Part 3: Discuss the functioning strategy of proposed framework. Part 4: Shows the recreation results and execution investigation of proposed framework. Part 5: Presents the end and future work of the proposed framework.

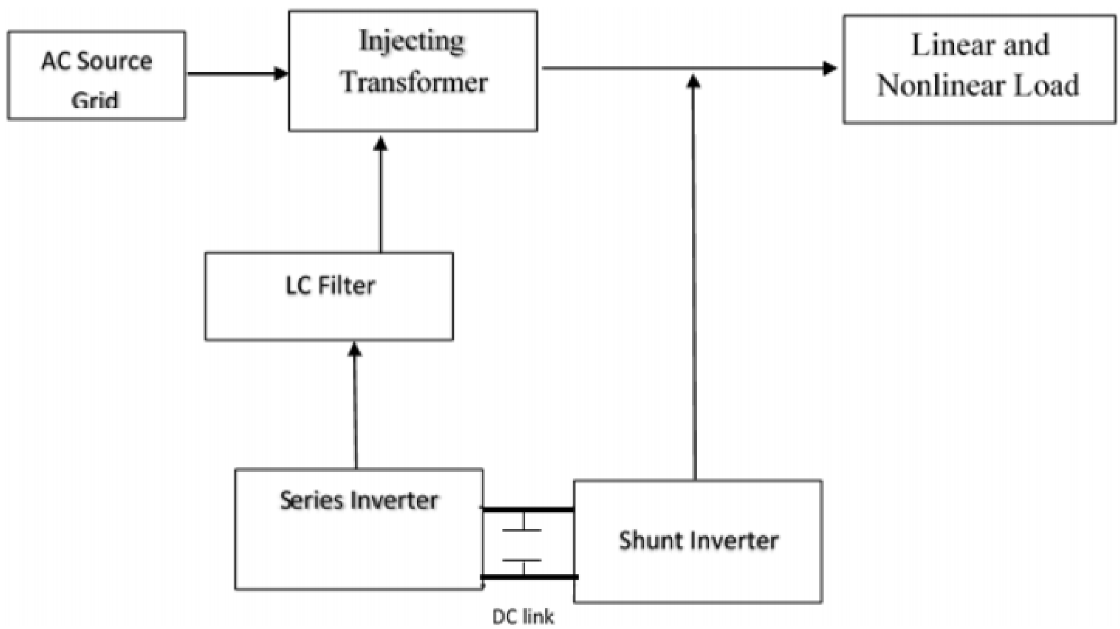

Fig 1 Single Phase UPQC

II. LITERATURE SURVEY

In the previous few decades, research including elective and sustainable power sources has developed essentially [7], as the reduction in the natural and financial effect on power is primarily because of expanded interest. Hydropower, biomass, wind, ocean and sun based, emerge among the few other option and environmentally friendly power sources. Thinking about this situation, the sun powered energy can be considered the most valuable of the accessible sustainable power sources. After its change of electrical energy, through photovoltaic (PV) exhibits, the sun oriented energy usage network can be infused utilizing foundational energy transformation conditions [8]. For the most part, for this reason, it is finished with DC-DC converters. The primary, PV structure voltage is supported and second it's associated with utility framework [9–11].

In various PV structures, the DC/change stage is smothered and the essentialness gave from the PV bunches is imbued genuinely into the framework using a DC/AC converter [12, 13].Due to the DC yield of the PV module, power gadgets converters are needed to change over the DC capacity to the AC lattice interface [14], which is an important DC-AC inverter. A fragmentary request (FO) regulator for lattice photovoltaic frameworks is introduced in [15] and by utilizing an unusual photovoltaic framework working in an autonomous matrix associated mode, a compelling arrangement especially reasonable for energy supply issues in the private area is talked about in [16]. In [17], to layout the upsides of a self-ruling sun oriented DC power multi-limit building, low-energy private burdens and instructive organizations, to save expenses and improve the idea of force and energy saving. The synchronization with the PV inverter lattice is done with the help of a Phase Locked Loop (PLL) [18–20].The principle work is to give a synchronization inverter activity of the PLL solidarity power factor is identified

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with the framework voltage by the yield current [21]. Need an UPQC as force conditioners for Single-stage and three-stage frameworks require, these issues are related to voltage and current, for instance voltage hang, expands, and THD are progressively expressed in single-stage systems [22–24].Several examinations have been acted in the PV network associated UPQC including altered SRF hypothesis [25], power point control techniques [26] and control designs of resounding regulators (PR-R and V-PI) [27, 28]. Most scientists should utilize the PI regulator to expand execution in the UPQC setup, yet this will diminish execution because of the non-direct nature of the framework [29].In [30] breaks down the exhibition of UPQC which is a typical DC transport capacitor sharing Series Active Power Filter (SAPF) and shunt/Parallel Active Power Filter (PAPF) mix. UPQC's and Left-Shunt inverter (LS-UPQC) are designed to forestall power quality issues when associated with an appropriation framework from non-sinusoidal force conditions under Combined Mode Control (CMC). A DSP-based shunt dynamic channel [31] is utilized to wipe out sounds and remunerate responsive force from non-direct burden conditions.

The strategies talked about above don't totally address power quality issues in lattice associated PV frameworks. Subsequently, this work proposes a solitary stage PLL structure that utilizes quadrature signals created by engendering delay. The fundamental downside of the ordinary strategy is its affectability to stage transfer speed changes, since the postpone time is dictated by accepting a steady recurrence.

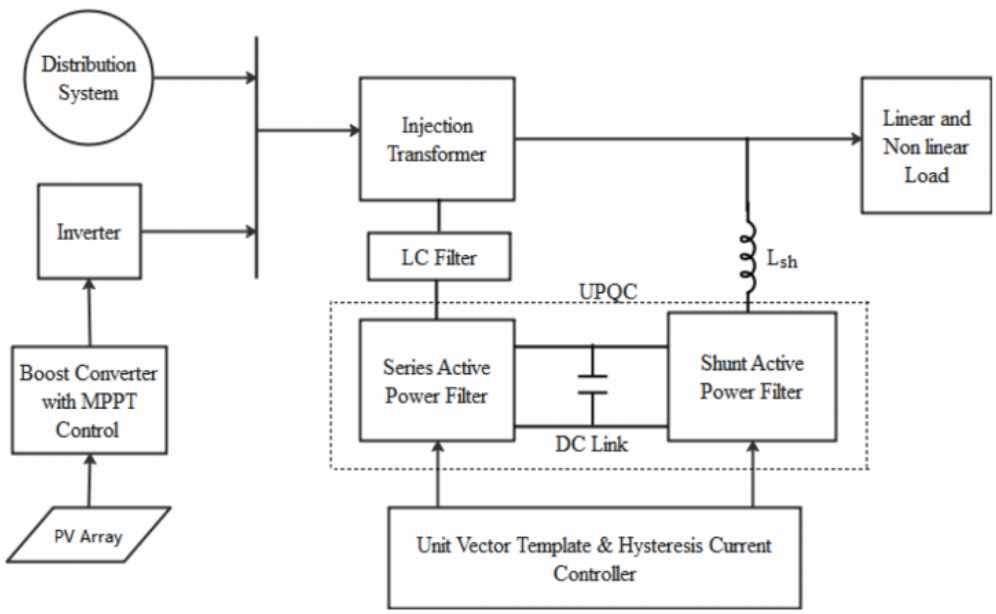

Fig 2 Proposed UPQC with Solar Grid Connected System

In addition to the MPPT and phase synchronous control, the other controller is need for grid is connected to the photovoltaic DC bus. Consequently in this work includes the utilization of single-stage Unified Power Quality Conditioner (UPQC) in view of a unit vector format control calculation for its capacities with framework joining of photovoltaic, for example, voltage lists/swell, unit power factor rectification, voltage and current consonant cancelation.

III. MATERIALS AND METHOD

The construction of the PV framework associated with the lattice with UPQC is appeared in Fig. 2, where the PV is associated with a DC-DC converter and will control the activity of the DC yield from the unregulated DC contribution by changing the obligation cycle. In this work obligation pattern of DC-DC converter is constrained by utilizing Perturb and Observe (P&O) calculation. The Pulse Width Modulation (PWM) method is used to convert photovoltaic DC voltage to an AC voltage at the line frequency, in this work focus on single phase inverter. The approved program also ensures that the DC voltage remains stable and does not change fast enough to ensure smooth operation and also PID controller is used to design the phase locked loop (PLL) to synchronize grid and voltage source inverter.

Finally, a unit vector template control algorithm has been used to control the operation of active filters for proposed PV grid connected UPQC to fulfill the standard specifications of voltage sag, voltage swell and current harmonics are injected into the grid. The high-impedance to high-frequency and low-

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impedance to low-frequency signals are obtained from UPQC to improve the power quality response.

A. PV array

A PV array consists of several photovoltaic modules connected in series and parallel, which define the maximum power voltage (VMPPT) and current (IMPPT), the short circuit current (ISC) and open circuit voltage (VOC). The mathematical expression of PV cell and PV array is described in Eqs. (1) and (2) respectively.

$$I_M = I_{PVCELL} - i_{oCELL}\left[\frac{\exp\left(\frac{QV_M}{NT_{AP}}\right)}{I_d}\right] - 1\text{----------------(1)}$$

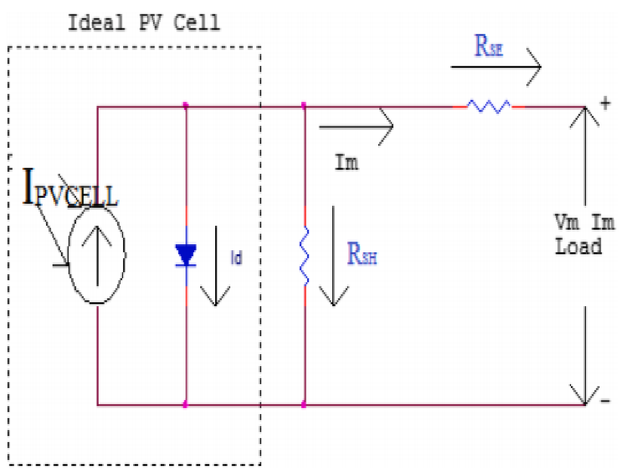

Fig 3 PV Cell Equivalent Circuits

$$I_A = N_{PV} I_{PVCELL} - N_{PR}\, I_{OCELL}\left[exp^{\frac{Q}{N_T KNT_{AP}}\left(\frac{V_M}{N_{SE}}+\frac{I_M R_{SE}}{N_{PR}}\right)} - 1\right] - \frac{1}{R_{SE}}\left[\frac{N_{PR} V_M}{N_{SE}} + I_M R_{SE}\right]\text{-------2}$$

VM = Voltage of PV module IM = Current of PV module The Equivalent circuit of PV cell is shown in Fig. 3. The output current response of the PV array is calculated using Eq. (2)

Where

NPR = Connection of Solar cell quantity in Parallel
NSE = Connection of Solar cell quantity in series
Q = Rate of Electron Charge
NT= Ideality factor
TAP = Temperature of PV module
VM= PV module voltage

Where

IPVCELL = Generated Current

IoCell = Represents Reverse Saturation Current of Diode

Q = Charge Rate of Electron

TAP = Temperature range of PV module

N = Constant of diode value

Id = Current value of diode

RSE= Value of resistance connected in series
RSH= Value of resistance connected in parallel
NPV= Quantity of PV cell
IM= Module Current
IA = Overall module Current.

B. Maximum power point tracking using P&O

The MPPT technique is utilized to improve the productivity of solar power generation. As per the Maximum Power Point Theorem, the MPPT calculation of any circuit yield power can be expanded by changing the source impedance equivalent to the load impedance, in this way MPPT technique proportionate to the impedance coordinating issue In the present work, the boost converter circuit is utilized as an impedance coordinating gadget between the information and the yield by changing the obligation cycle.

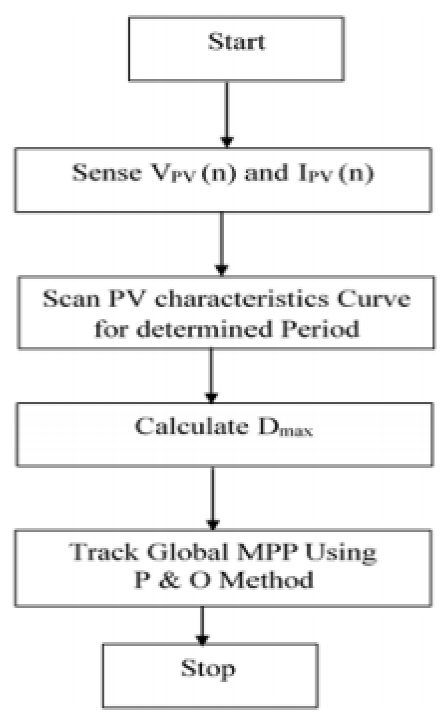

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Fig 4 Flow Chart of P&O Method

A significant preferred position of the boost converter is the high or low voltage that is acquired from the accessible voltage as per the application. The MPPT is used to calculate the duty cycle to obtain the maximum output voltage, and the output of the converter is a response that depends on the duty cycle. The perturbation and observation (P & O) method was used in this work to obtain the maximum power from the PV the proposed commitment depends on the duty cycle utilizing the Underlying estimation of the variable. Where the calculation computes the underlying worth immediately at whatever point there is a continuous change in the information of irradiation.

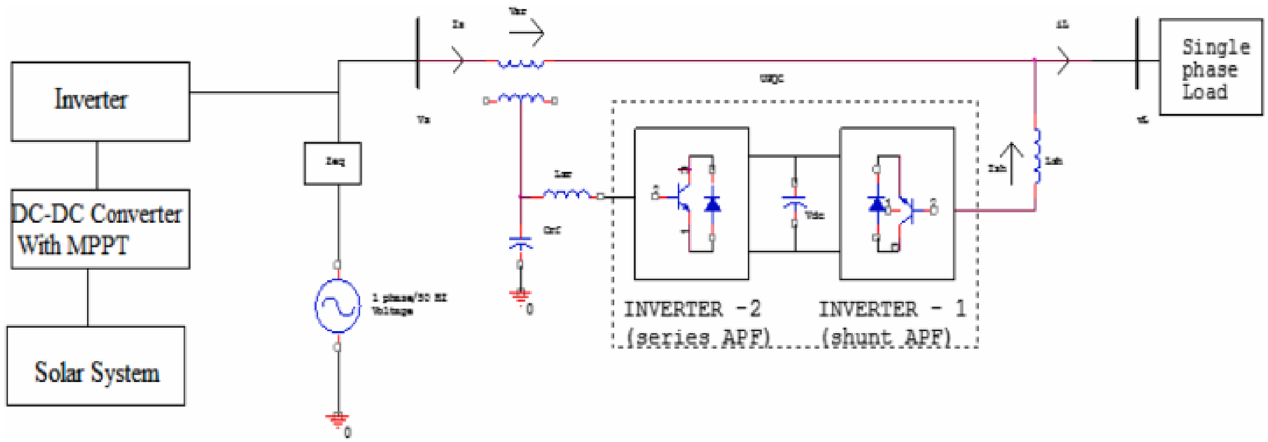

Fig 5 Functional Diagram of proposed system

C. Single phase UPQC

The proposed control strategy aims at generating a reference signal for voltage in the PCC. Fig. 5 shows the proposed system functional configuration diagram at low powers, the active resistance between the inverter and the grid cannot be neglected. It is controlled by the dynamic obstruction of the inductive curl, the conductors and furthermore by the protections of the force extension's semiconductors. For this situation the yield lattice current is

Determined by the impedance Z between the inverter and the grid and by the difference between the two voltages

$$V_Z = V_{inv} - V_{grid}\,,\ I_{Out} = \frac{V_{in} - V_{grid}}{Z} - - - - - (3)$$

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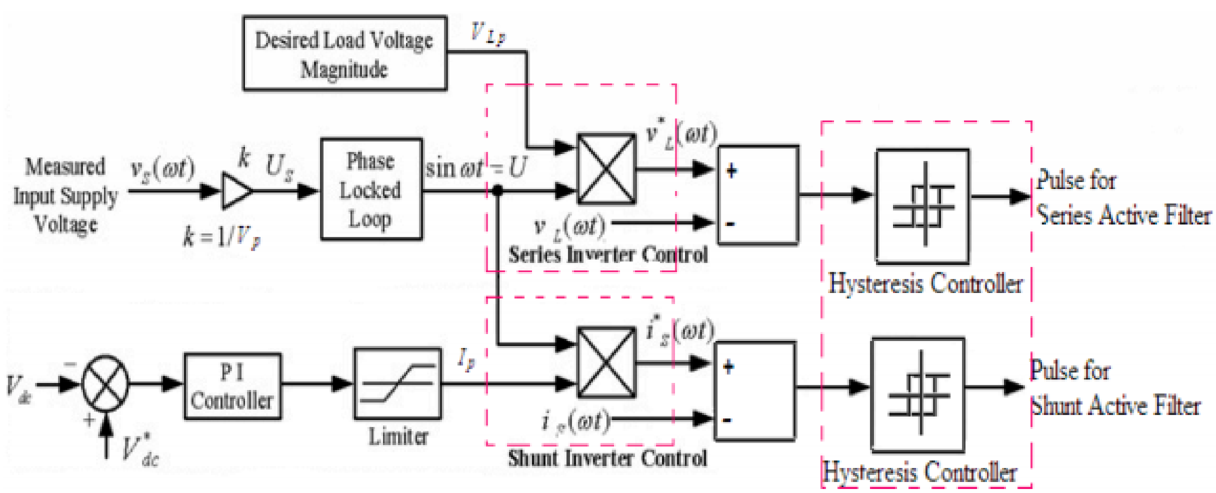

Fig 6 Circuit diagram of single phase UPQC with UVTG

Where

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VZ =Voltage drop on the impedance Z
Vinv = RMS value of the first harmonic for output of inverter voltage
Vgrid= grid voltage.

D. Control scheme of series active power filter

The main function of the UPQC's Series Active Power Filter is to maintain the load bus sine curve and rated voltage. Therefore, the easiest way is to directly load the load bus voltage perfectly sine curve to create a series of converters with gestures to match it. For instance, the buyer utilizes a solitary stage 230volt AC/50 Hz voltage for a standard home, for instance the standard size of the provided voltage is fixed. So the two primary variables are explicitly evaluated at the key recurrence (eg 50 Hz),

(i) The sine curve voltage sensitivity at constant load voltage range is protected and

(ii) For proper load, to maintain accurate control of the load bus.

The power supply voltage might be twisted and may give some droop or voltage rise because of undesired conditions in a similar feeder, for instance, turning ON/OFF of high appraised load, capacitor bank, and so on. In this case, if the load voltage is imperative and the sine curve needs to be fixed, the load voltage range can be determined and unwanted events / problems can be easily solved. This is the necessary voltage, so the state will make the sine bend voltage entirely after the ideal reach, so these This arrangement Active Power Filters (APF) can be controlled with the goal that the force voltage mutilation is at present dropped. In other words, the amount of voltage applied by the power is passed through a series of filters to the required voltage.

E. Control scheme for shunt APF

The unit vector template used to generate a reference current signal to the shunt APF. The principle capacity of the shunt APF is to keep up the DC voltage at a steady level, which settles the present synchronization and also reactive power. The most effortless approach to make up for the above issues related with load is to compel the source current sinusoidal wave.

F. Control strategy of UPQC

The control circuit of single phase UPQC with unit vector template generation (UVTG) is shown in Fig. 6.

- Generation of reference voltage signal for series active filter

Supply voltage distortion was sensed, and an experiment for which two orthogonal unit vectors provides for the production of a single-phase locked loop (sinwt, coswt). The sinusoidal voltage using the expected peak phase formula with which the PCC output from the PLL (V∗ lm)) is multiplied using Eq. (9)

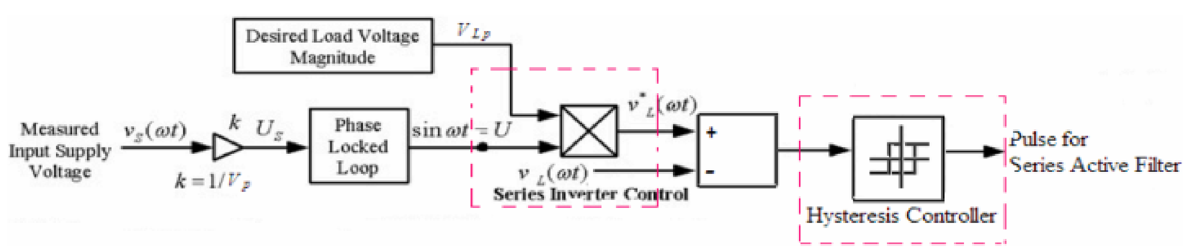

Figure 7 Circuit diagram of single phase Series Active Filter

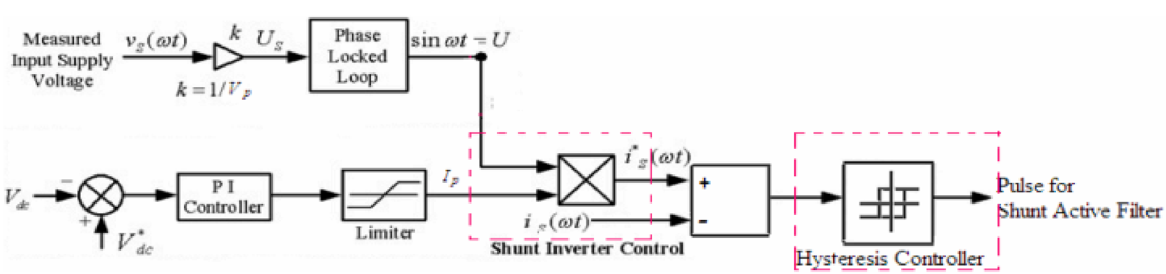

Fig 7 Shunt Active Filter Control

Table 1

Details of simulation parameters

Parameters	Values
Source	Solar energy
Boost converter	Inductor = 6mH, MOSFET
inverter	Bridge arm = 2, snubber resistance =250ohm, snubber capacitance= 0.1e-6
DC link voltage	Cdc=220µF and Vdc =400v

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V grid	230±10%v
Rate of non linear load	Active power =200w

$$[v_s^*] = v_{lm}^* \, [lsin(wt)] \text{-----(4)}$$

Because of the voltage variation of the non linear- load gave by PCC (VS), this voltage can be decayed into the aggregate of essential (Vsf) and higher consonant segments (Vsh) and scientifically communicated as

$$V_s\,(wt) = V_{sf} + V_{sh} \text{----------(5)}$$

The harmonics term can be further expressed as,

$$V_{s,a,h} = \sum_{n=2}^{\infty} V_{s,a,n}\,(n\omega t + \theta_{na}) \text{------(6)}$$

Where,
Vs a, h = Amplitude response harmonic component voltage
SVs a, n = Amplitude response of nth harmonic voltage
n = harmonics order
θna = nth harmonic's phase angle

The series active filter with UVTG control is shown in Fig. 8. For a completely sinusoidal single-phase system only the fundamental component should be presented and the higher harmonic components should be necessarily zero. A straightforward method to diminish the heap voltage as a fundamental wave part of a PLL is depicted. First note is where the supply voltage represents the peak amplitude; the supply voltage gain equals amplifier internal 1 / Vp, VP. It provides a roughly balanced voltage profile. The sign with this brought together voltage is then described by a solitary section PLL. The sine and cosine functions of the PLL basic frequency band are output by the user given terms, in this case 50 Hz. The output sine and cosine signals have unit amplitude. This term signifies a perfect sinusoidal unit voltage signal. Unit vector templates for single-phase systems can be given in Eq. (7).

$$U = \sin\,(\omega t) \text{-----(7)}$$

As recently examined, the amplitude of load voltage is a known amount for a specific application. The format VLP is duplicated by the unit vector created by the condition (12), it is conceivable to effectively produce the necessary design record for the load with the ideal load voltage on the transport.

IV. RESULTS AND DISCUSSION

The framework comprises of UPQC to improve the PQ of a network attached framework with non-direct burden comprising of control hardware based on SCCS. The load is of converter fed resistive load. The performance of existing UPQC for a 3P3W system has been realized with the simulation through MATLAB Simulink software. The simulation parameters are given in the Table 1.

The proposed method analysis of proposed unit vector template control method UPQC system. The proposed UPQC system is interface with single phase grid-connected PV system and the simulation was developed using MATLAB/Simulink software (Table 1). The Simulink model of without UPQC dependent on PV lattice associated framework is appeared in Fig. 9, in this Simulink perturb & observe method is used for MPPT purpose. The simulation model of proposed single phase photovoltaic grid connected system with UPQC is shown in Fig. 11. In this work perturb & observe MPPT algorithm is used to generate the maximum power; Phase Locked Loop is used for grid synchronization and unit vector template method used for reference voltage generation.

The Fig. 14 discusses the voltage response of photovoltaic system. The simulation result of PV voltage s 72v and this voltage is fed to DC-DC boost converter circuit. The simulation result of DC-DC converter is appeared in Fig. 14(b). The above Fig. 14(b) discusses the DC-DC boost converter's voltage response. The response of the DC-DC boost converter is controlled by changing the duty cycle of MOSFET. Normally the output voltage of DCDC converter high, as compared with solar voltage The PV-Inverter Voltage response is shown in Fig. 14(c). The peak value of inverter is 230 V and this inverter is connected to grid source with parallel connection. The sag and swell response of the proposed single phase photovoltaic grid connected system is shown in Fig. 14(d). Fig. 14a shows the source voltage of soalr, Fig. 14(d) shows the transformer infecting voltage at PCC and the output voltage is shown in Fig. 14(e). In this work sag was occur from 0.15 s to 0.27 s and voltage swell was occur from 0.37 s to 0.43 s.

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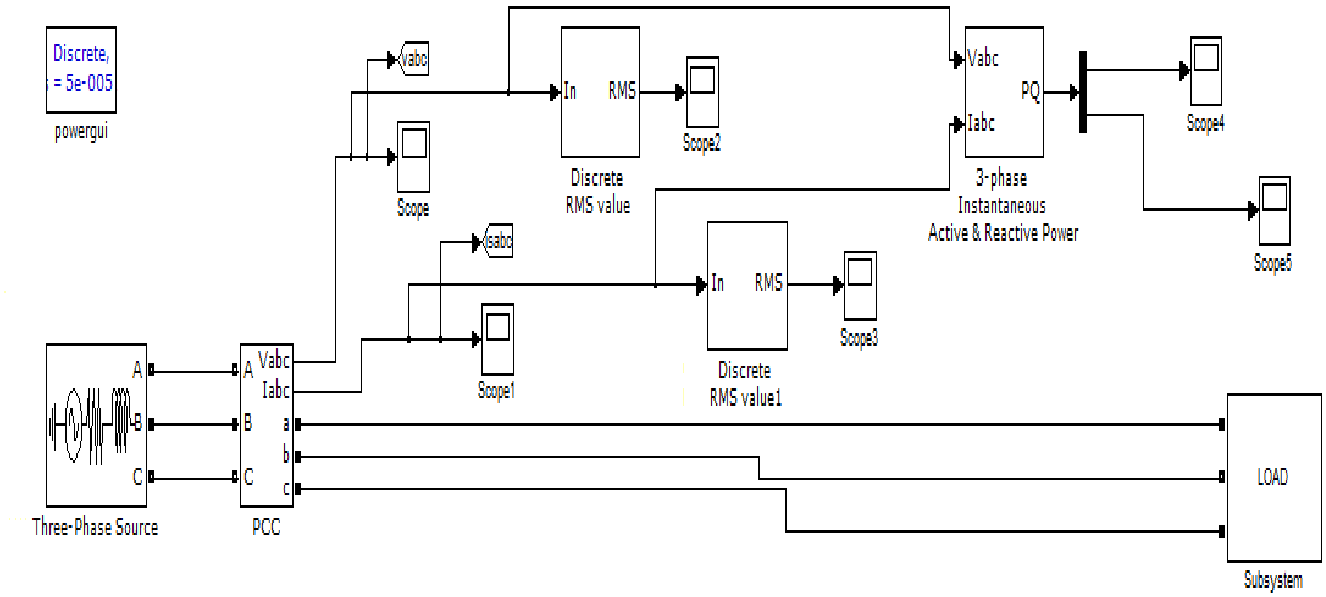
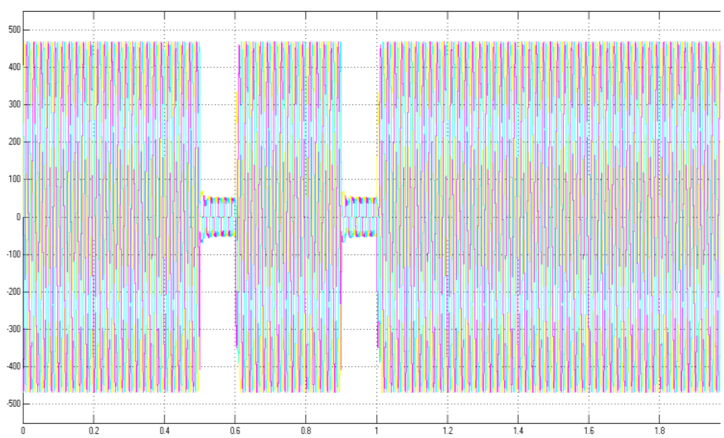
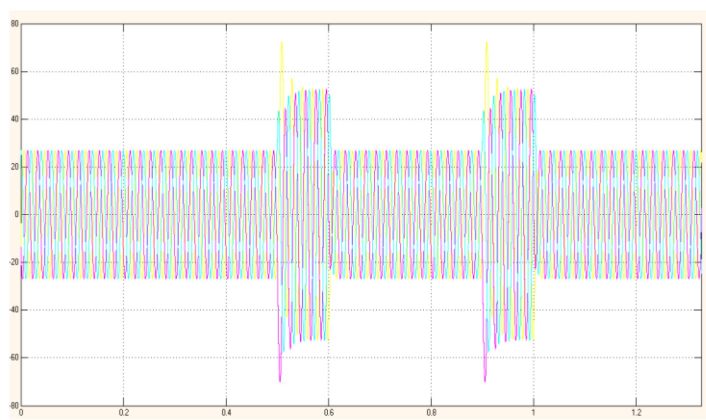


Fig8 Mat lab designs without UPQC



(a)



(b)

Fig 9 (a) source voltage without UPQC, (b) source current without UPQC

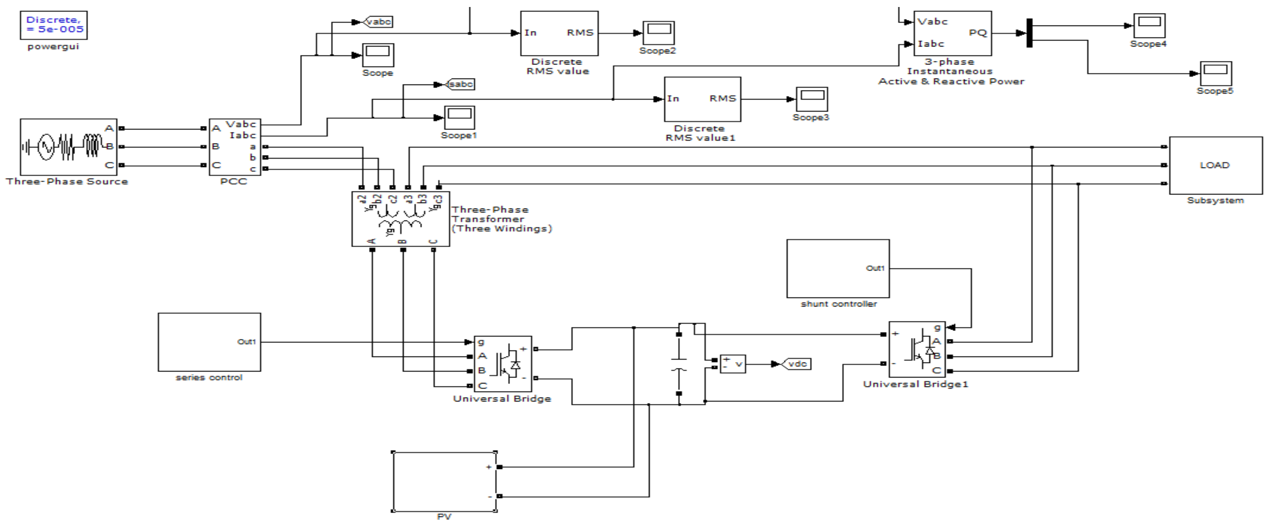
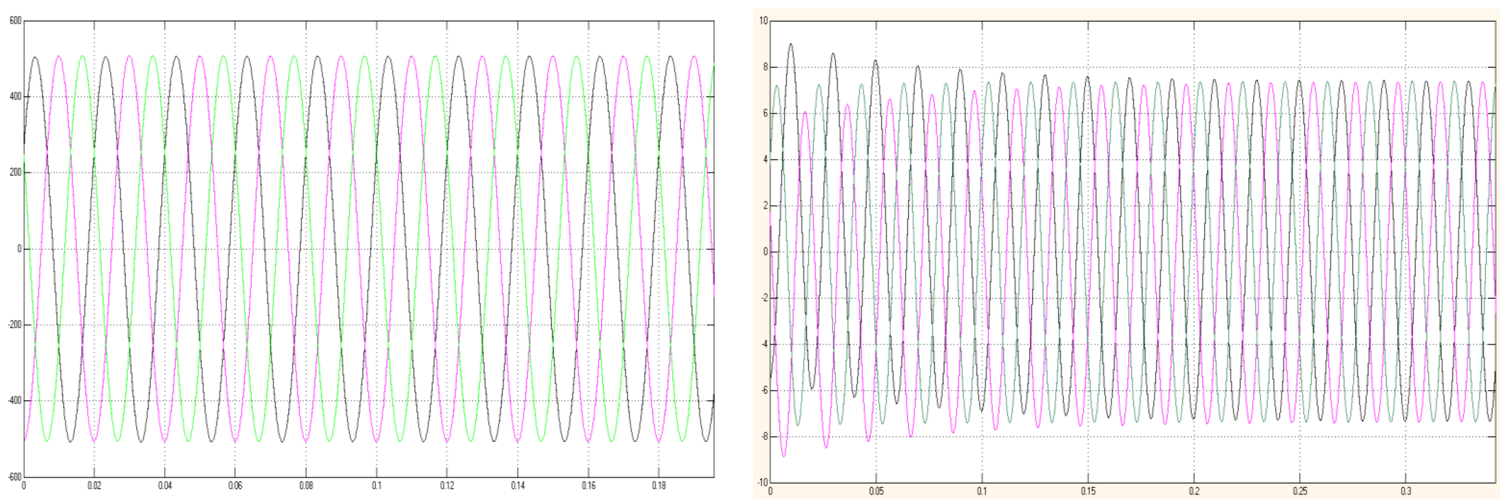


Fig 10 Matlab design with UPQC



(a) **(b)**

Fig11 (a) source voltage with UPQC, (b) source current with UPQC

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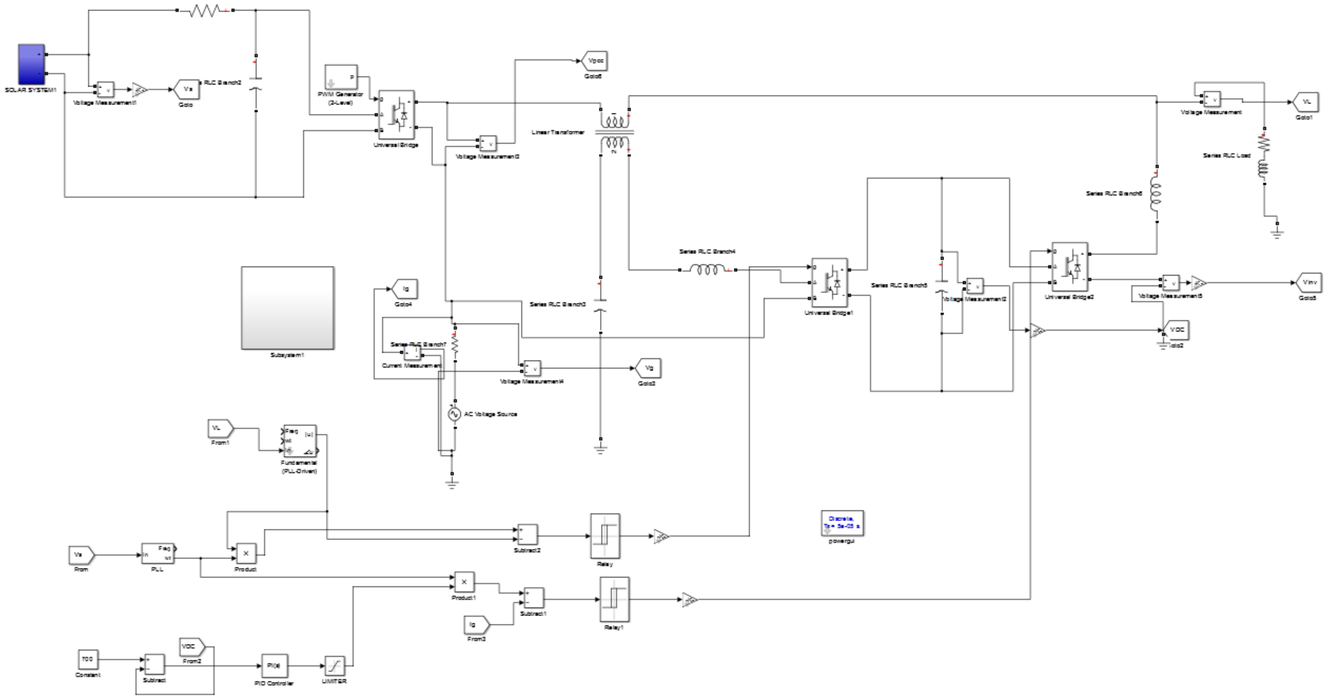

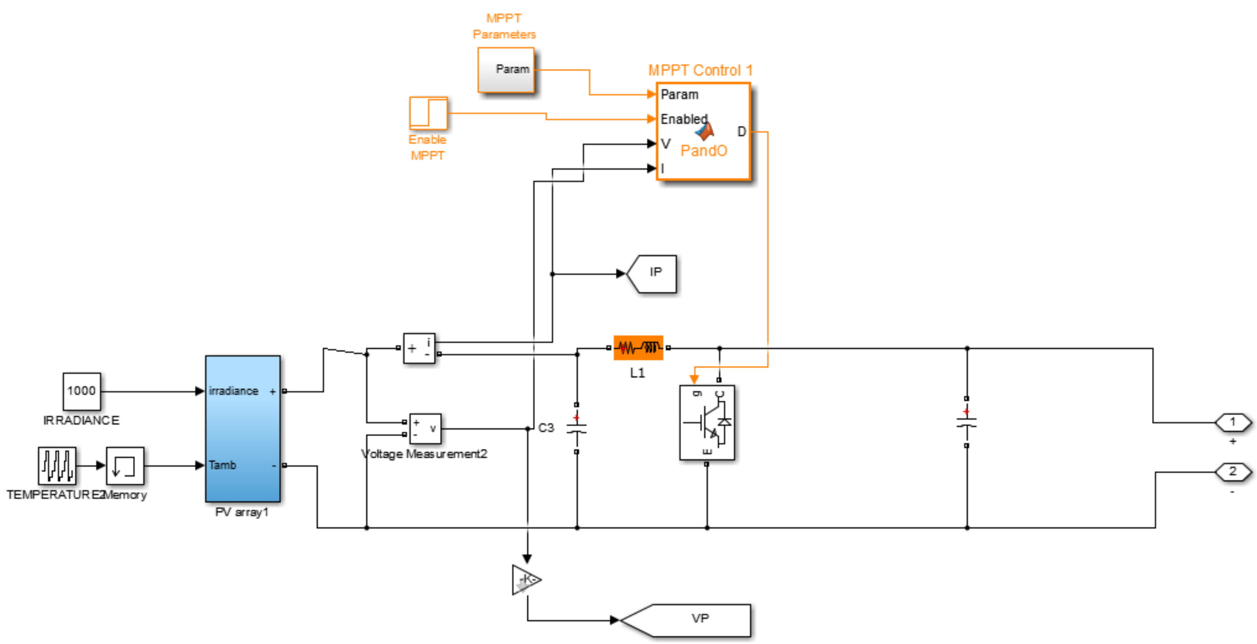

Fig 12 Matlab design UPQC UVC Control Theorem

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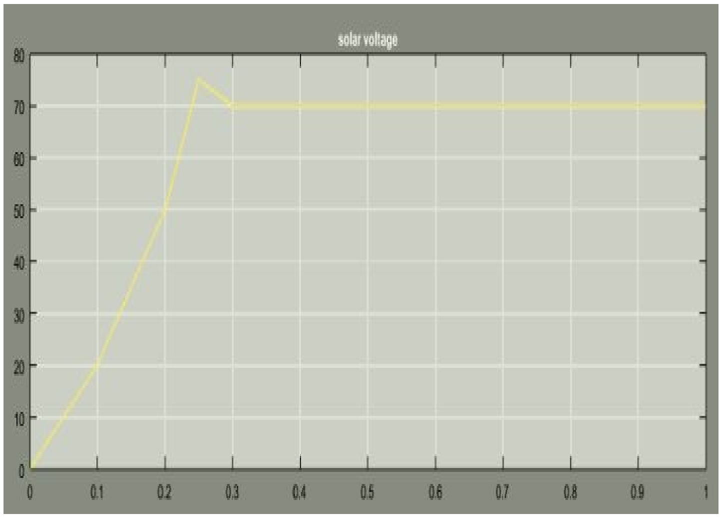
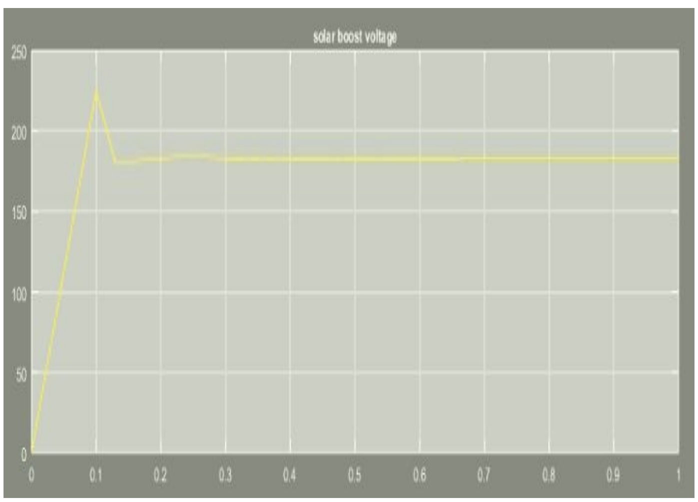
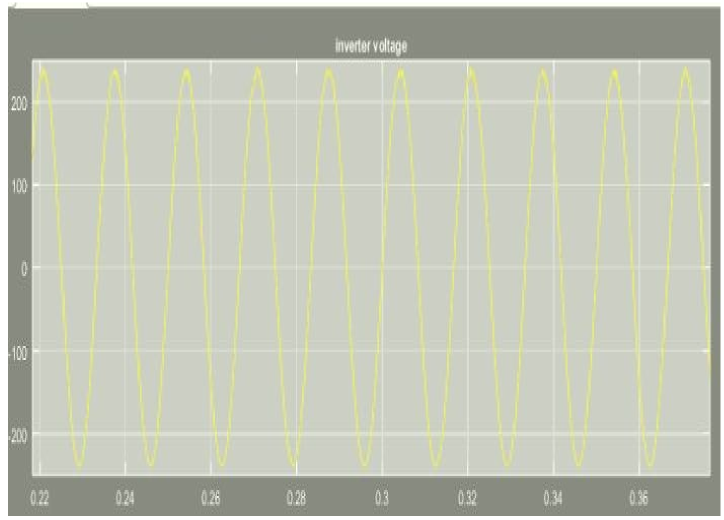
RESULTS:



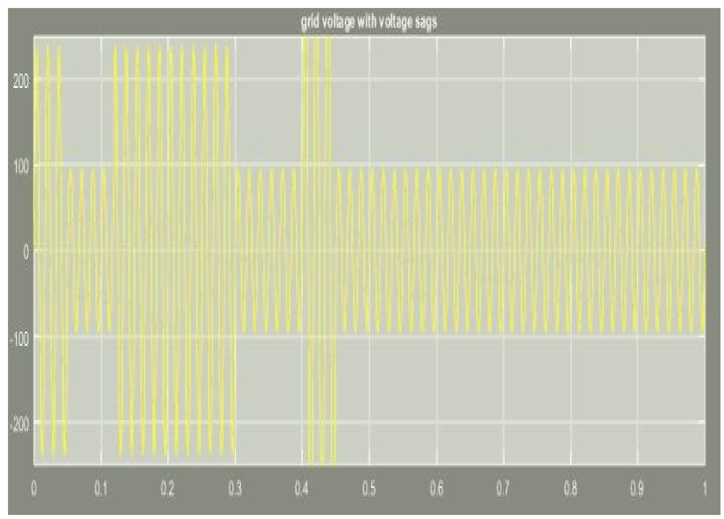
(a) Solar voltage



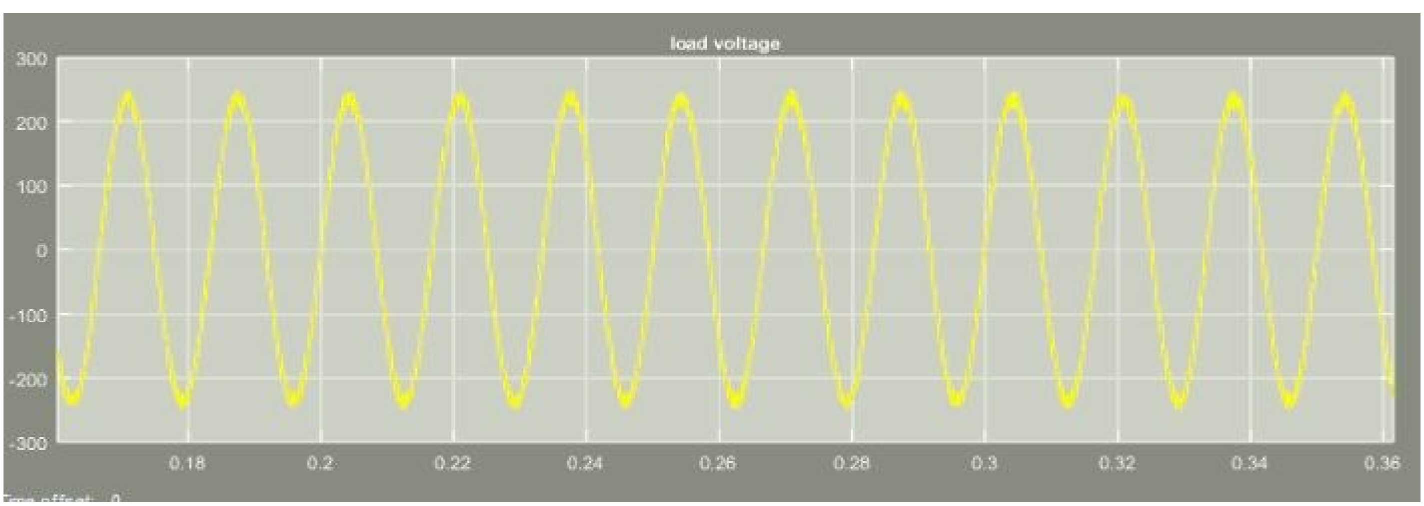
(b) Boost voltage



(c) Inverter voltage



(d) PCC voltage with sag and swells



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(e) Load voltage without voltage sags and swells

Fig 13 simulation results (a) Solar voltage, (b) Boost voltage, (c) Inverter voltage, (d) PCC voltage with sag and swells, (e) Load voltage without voltage sags and swells

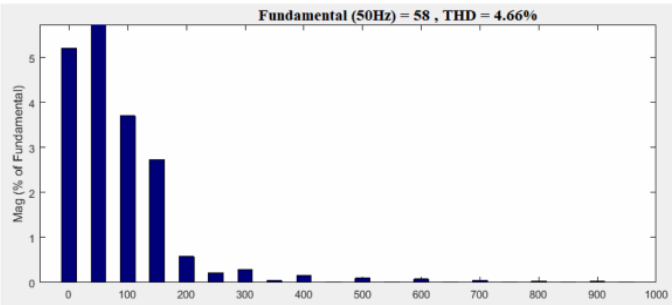

Fig 14 THD response of Proposed System

The simulation result of with UPQC based on solar grid connected system is shown in Fig. 14. In without UPQC the THD response 55.27%, which is higher than IEEE standard? The result of Total Harmonic Distortion for proposed system is shown in Fig. 15. In this work using unit vector template matching method. The THD value of proposed system is 4.66%, which comes under IEEE standard. The performance evaluation of MPPT and THD response in this comparison clearly states, as compared with existing incremental conductance method [32], the proposed system obtain best result. For example the THD for template matching with UPQC is 4.66% and THD for without UPQC and template matching is 55.27%. Compare to existing method UPQC with UVC theorem gives better results.

V. CONCLUSION

In this work presents, a single phase grid connected PV system. Albeit the framework is intended to run as planned on the solidarity power factor to empower productive utilization of full inverter limit, it runs on any ideal force. Utilizing the Perturb and Observe (P&O) calculation to guarantee MPPT execution, it can easily follow changes in daylight without swaying. The reenactment and test outcomes show a generally excellent match. The examination will cover the MPPT method, voltage control and current control of the framework. The proposed unit vector template matching with UPQC gives the best results against all parameters, for example output of solar cell per unit is 0.94, steady state error 8%, and MPPT efficiency 96.56% and THD is 4.66%.In this study, UPQC developed a hysteresis controller based on a single phase UVTG approach and simulated three cases of voltage sag/swell, unity power factor correction, voltage and current synchronization. The Total Harmonic Distortions (THDs) of proposed grid integration of photovoltaic systemsalong with single-phase unified power quality conditioner (UPQC) obtain the range of IEEE standard because the THD is less than 5%.

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