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Current Quality Improvement by Photovoltaic Integrated-UPQC-S Using Modified PQ-Theory

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Abstract–A modified active and reactive (PQ) basedcontrol theory used by a solar photovoltaic-array which is an integrated power quality conditioner is proposed in this paper. Clean energygeneration is incorporated by this system and powerqualityimprovement is also provided these characteristics of unified power quality conditioner increases the efficiency of the system. Underdistorted point of common coupling voltage conditions, this modification provides a great advantage. The basic regularity of voltages components having positive sequence is extracted from common coupling using delay signal cancellation technique. The delay signal cancellation technique is a generalized cascaded technique and this cancellation technique is used in pq-theory to assess the signals of UPQC-S. PV array is combined with dc bus of unified power quality conditioner it provide part of the active load power and hence the demand for supply system is reduced. The enactment of PV-UPQC-Sis verified by doing the simulation of the system using MATLAB-Simulink. The verification is done by combing linear and nonlinear loads.

Index Terms –Photovoltaic (PV)-array**,** Point of common coupling (PCC), Generalized cascaded delay signal cancellation (GCDSC), Phase lock loop (PLL), Delay signal cancellation (DSC)

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I. INTRODUCTION

A collective necessity for renewable energy systemswhich has additional features especially where there is low voltage distribution system. If the quality of the power is low then there will be high power loss and it may lead to displeasing conduct with adjacent communication lines [1]. This paper emphasizes on unified power quality conditioner is basically from APF family. In UPQCshunt and seriesAPF is combined to increase the quality of the power so the power quality can be improved at distribution level.UPQC categorization can be done as 1) current or voltage sourceconverter2) two-wire, three-wire, three-phase 3) new configurations for three-phase system [2].Although power electronic loads are energy competent, harmonic currents are Injected into the grid which leads to misrepresentation may occur at PCC especially in a weak grid system. Sensitivity of power electronic loads to voltages may also cause distortion and there may be voltage fluctuations in a weak distribution system because of the sporadic nature of energy sources for example solar energy and wind energy.
Due to the fluctuations in voltage it can affect sensitive power electronic load for example lighting systems it may chances of tripping the electrical system which will increase maintenance costs. A PV-UPQC-S photovoltaic (PV)-array-integrated system will generate clean energy and quality of the power is also improved, thus making the system efficient [1].PLL is a 3 phase cascaded signal is used for selective harmonic detection and unwanted harmonics is totally removed which would result in steady-state error detection. Multiple harmonics can be tracked by parallel arrangement of numerous CDSC operators is proposed[3]. PLL structure uses non-adaptiveGDSC operator as an initial stage of filtering. In the case of frequent drifts, PLL structure uses two units known as PEC [phase-error compensator] and AEC [amplitude-error compensator] for scaling of amplitude and phase shifting.PEC [phase-error compensator] and AEC [amplitude-error compensator] is used in post processing [4].

In distribution systems of low-voltage there is a high demand for renewable energy systems. The solution is an UPQC-S proposed in this paper, shunt VSC has an advantage of improved load voltage regulation and It also provides improved grid current quality. The paper proposes an improved PQ theory algorithm this algorithm of PQ theory is based on GCDSC. It allows PV-UPQC-S operation below adulterated voltage conditions.

PV array integrated with dc link of PV-UPQC will reduce the demand of supply system load, maintenance cost is reduced, quality of power is improved, and frequent of power tripping is reduced.

II. MODELLING OF PV-UPQC-S

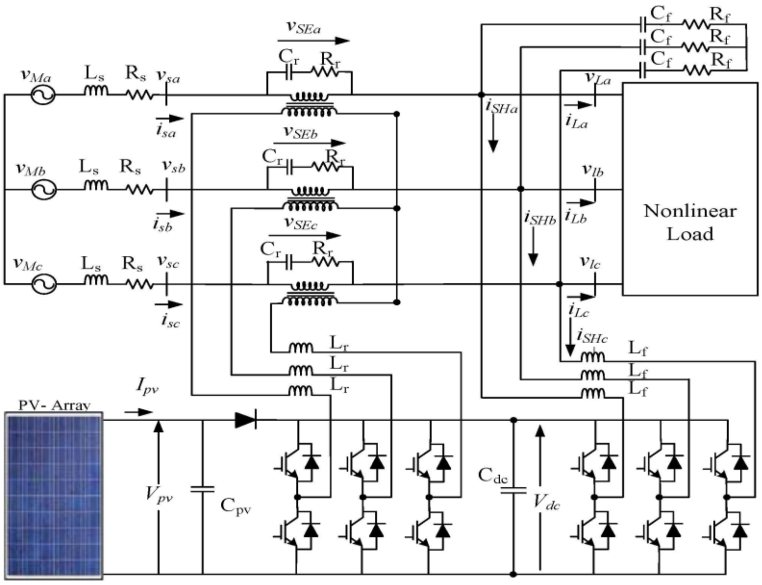

Fig 1. Block diagram of PV-UPQC-S

PV-UPQC-S is shown in Fig.1.It consists of 2 parts series VSC and shunt VSC. They are linked back to back using a DC-bus which is common for both.Interfacing inductors are used to connect to grid of VSC's.Switching harmonics are filtered using Ripple filters.

Voltage is injected through series transformer in VSC.Reverse block diode is used to connect DC bus and SPV array. The fig.2 shows the Simulink model of PV-UPQC-S

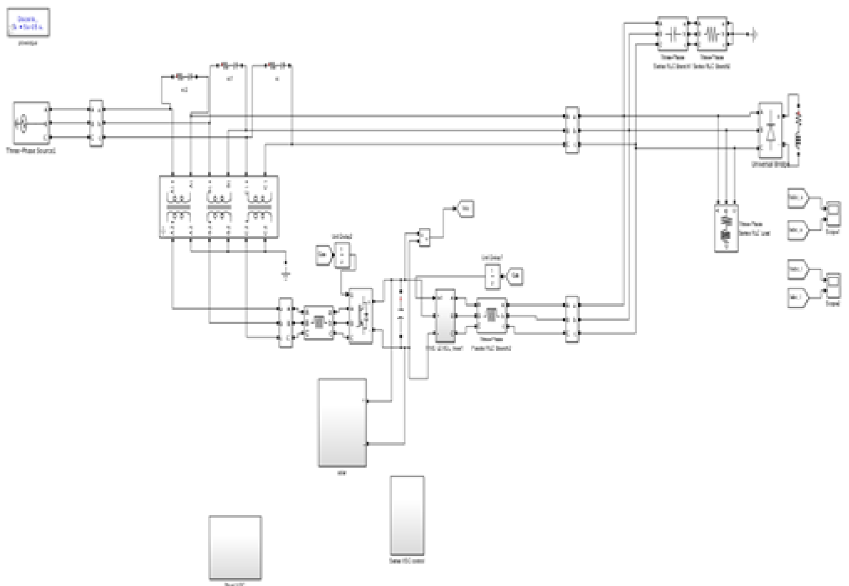

Fig 2.PV-UPQC-S model using Simulink

III. PV-UPQC-S CONTROL

A. GCDSC BLOCK

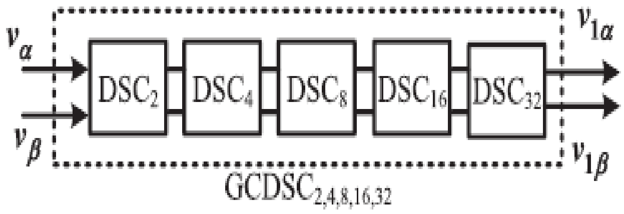

Fig 3. Block diagram of GCDSC

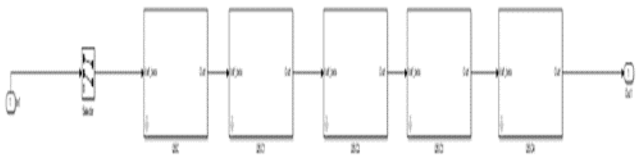

Fig 4. GCDSC model using Simulink

This type of cascaded block is used when the harmonic is unknown at common coupling is shown in fig.3. The harmonic is eliminated by 5 cascaded connecting DSC' block with delay factor N
FFPS component is extracted using the equation 1

$$v_{h\alpha-\beta}(t) = \frac{1}{2}\left[v_{\alpha-\beta}(t) + e^{j\frac{2\pi}{N}} v_{\alpha-\beta}\left(t - \frac{T}{N}\right)\right] \quad (1)$$

$v_{\alpha-\beta}(t) = v_\alpha + jv_\beta(t)$
$v_{h\,\alpha-\beta}(t) = v_{h\,\alpha}(t) + jv_{h\,\beta}(t)$ FFPS component
Harmonics=N×k+ 1 (of αβ domain,
T =basic voltage period,
N= delay factor.
Equation 2 details on DSC operator transfer function

$$G_N(j\omega) = \left|cos\left(\frac{\omega T}{2N} - \frac{\pi}{N}\right)\right| \angle - \left(\frac{\omega T}{2N} - \frac{\pi}{N}\right). \quad (2)$$

B. Load Power Calculation Block

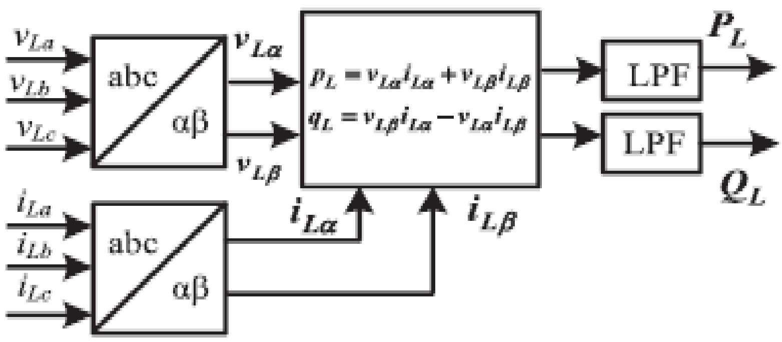

Fig 5. Block diagram of load power calculation

VLa,VLb,VLc are the load voltage
iLa,iLb,iLc are the load currents
PL,QL are the load active and reactive power in the fig.5
The load voltages $v_{L\,a}$, $v_{L\,b}$, $v_{L\,c}$ and load currents $i_{L\,a}$, $i_{L\,b}$, $i_{L\,c}$($v_{L\,\alpha}$, $v_{L\,\beta}$) and load currents ($i_{L\,\alpha}$, $i_{L\,\beta}$).The rapid active and reactive powers p_L and q_L are passed into the LPF to get the basic P_L and Q_L

C. **Control Structure Of Shunt Vsc**

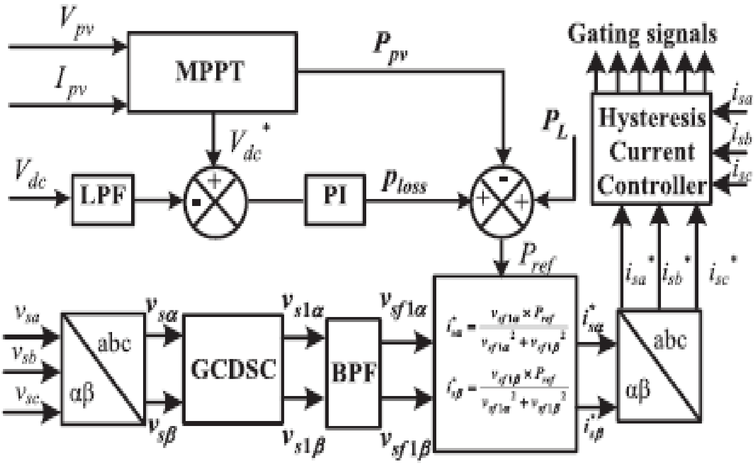

Fig .6. Shunt VSC control structure block diagram

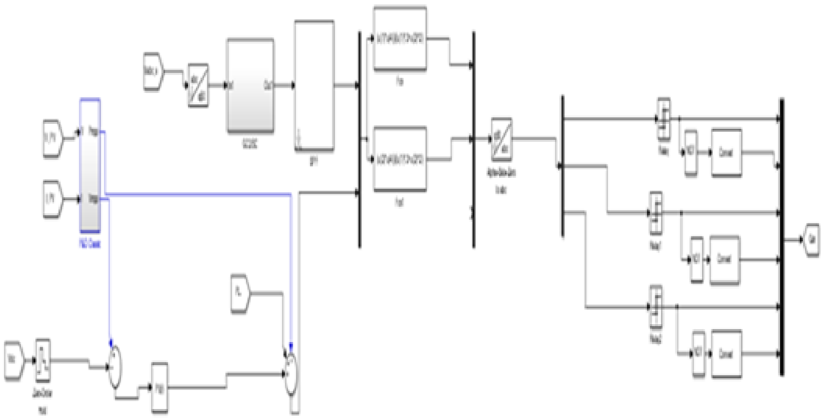

Fig .7. Shunt VSC control structure model using Simulink

The shunt VSC control block diagram is presented in Fig. 6.
P_{ref} is the reference power,
P_L is the load power,
$P_{loss}$is the loss component from PI integral,
Ppv power from pv panel
i α*,i β* is the reference grid current

Problem's related to power quality such as unbalanced load, inaccurate current, mitigated by shunt VSC .Using MPPT algorithmdc voltage reference value is obtained.PV array's max power is obtained using P&O algorithm. The dc bus (Vdc)
Is given as an input to LPF.(Vdc∗).is compared with Vdc.Vdc error and Vdc∗ error is given to PIcontroller, Hence the loss is computed Ploss.The power Pref is given by

$$P_{\text{ref}} = P_L + P_{\text{loss}} - P_{\text{PV}}. \qquad (3)$$

GCDSC block gives $v_{s1\alpha}$ and $v_{s1\beta}$.

$$i_\alpha^* = \frac{v_{sf1\alpha} \times P_{\text{ref}}}{v_{sf1\alpha}^2 + v_{sf1\beta}^2} \qquad (4)$$

$$i_\beta^* = \frac{v_{sf1\beta} \times P_{\text{ref}}}{v_{sf1\alpha}^2 + v_{sf1\beta}^2}. \qquad (5)$$

D. **Series Vsc Control Structure**

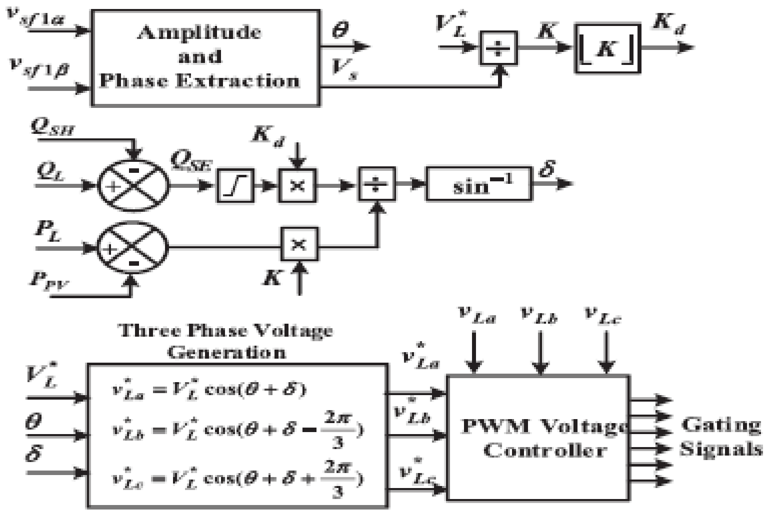

Fig 8. Series VSC control structure

Fig. 8. Gives series VSC representation which protects the sensitive loads from voltage related problems.Compensation for load is given by series VSCTheassociation of power angle I given by δ and is given in equation 6

$$\delta = \arcsin\left[\frac{Q_L - Q_{SH}}{P_L - P_{PV}}\right] \quad (6)$$

QL is the load reactive power
QSH is reactive power of shunt converter
PL is the load active power
Ppv is power from PV array
δ is the power angle

$$\delta = \arcsin\left[\frac{Q_L - Q_{SH}}{K(P_L - P_{PV})}\right] \quad (7)$$

K is load reference voltage
PCC voltage is given by peak VS

E. **Solar Pv Array Desgin**

The solar pv array working based on the solar photovoltaic principle.the desgin parameter of FIRST SOLAR FS-272
Open circuit voltage (Voc) = 94.57 V
Maximum voltage (Vmax) = 70.88 V
Short circuit current (Isc) = 1.18 A
maximum current (Imax) = 1.010 A
twelve number of series connected module per string and twenty four number of parelell string are used to construct PV array

IV. RESULTS AND DISCUSSIONS

In this section we will discuss simulation results of steady state and dynamic performance of a PV-UPQC-S using MATLAB and Simulink software

A. Steady State Condition

The steady state performance of the PV-UPQC-S is shown in fig.9. the nonlinear load causes the total harmonic distortion at supply side and load side because current is not sinusoidal with respect to voltage which leads to THD.in order to reduces the %THD the PV integrated UPQC-S is connected in the point of common coupling.

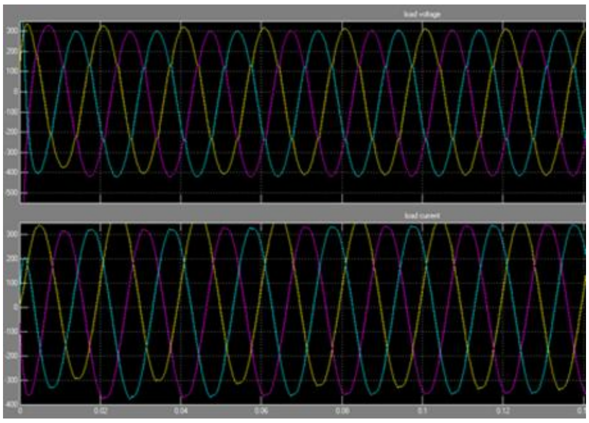

Fig 9. Steady state performance of PV-UPQC-S

It can be observe that up to 0.15S initial disturbance after that the load current is sinusoidal.by connecting PV-UPQC-S the disturbance caused by the nonlinear load is mitigated and also the FFT analysis in the MATLAB Simulink at 50Hz fundamental frequency load current distortion is 2.60%, which are within the limit prescribed in IEEE-519.

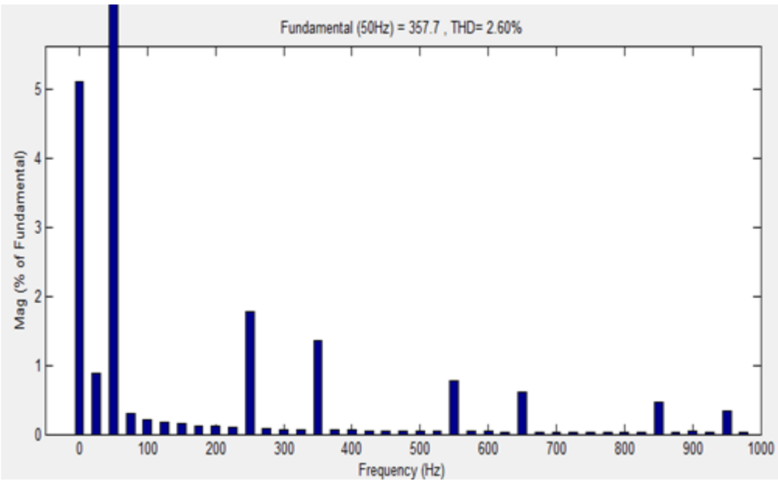

Fig. 10.THD in FFT analysis

B.Dynamic State Condition

The PV-UPQC-S is presented in fig.11 it can be observe that the shunt VSC maintaining grid current balanced. The load current is settle with in the 0.2S.And also the FFT analysis shows at 50Hz fundamental frequency 2.84% load current harmonic distortion which are within the limit.

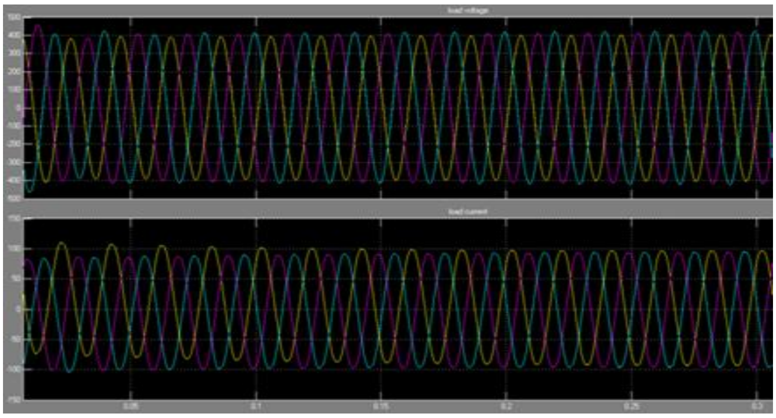

Fig. 11. Performance of UPQC during load unbalanced

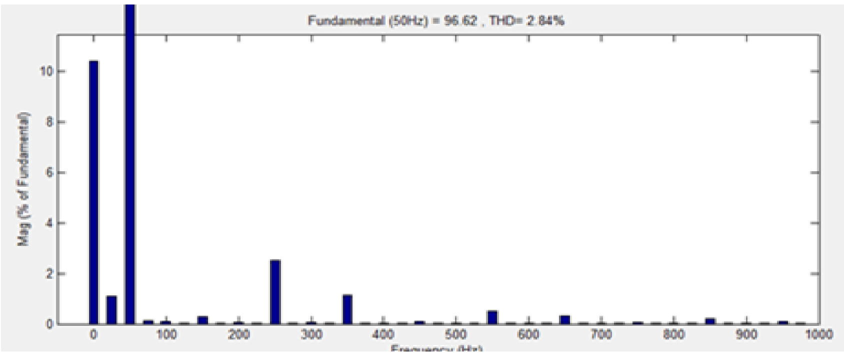

Fig. 12. THD in FFT analysis during load unbalanced

Irradiation change PV-UPQC-S performance is presented in fig 14.UPQC dc bus is integrated with PV array, hence demand on supply system is reduced.it is evident that the integrated photovoltaic shares active power of the load is shown in fig'.13

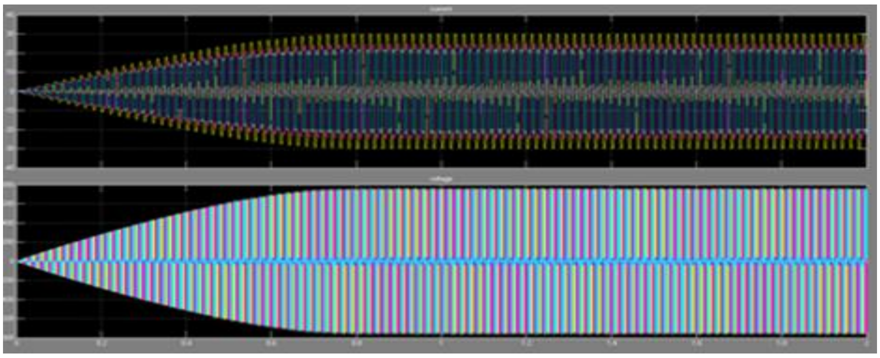
Fig. 13. Current and voltage supplied by PV array

Due to the intermittent nature of solar energy fluctuations is increased based on load demand, during this condition PV-UPQC-S compensate load current and voltage fluctuations.it can be observe that the total %THD is 1.66% in FFT analysis

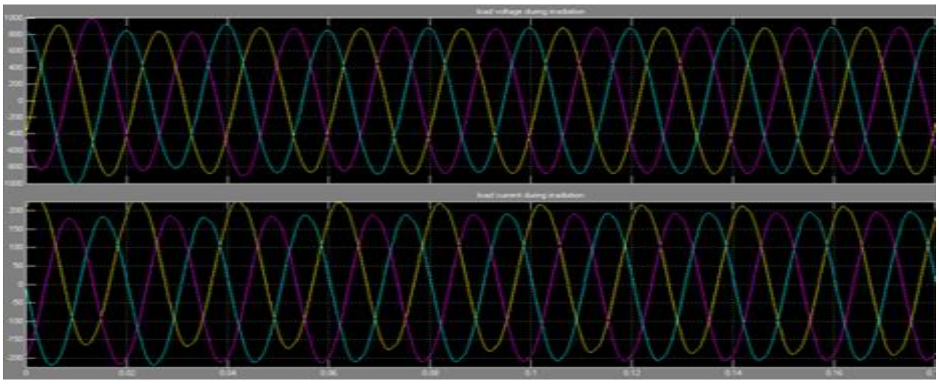
Fig. 14.Load current and voltage of PV-UPQC-S during irradiation change

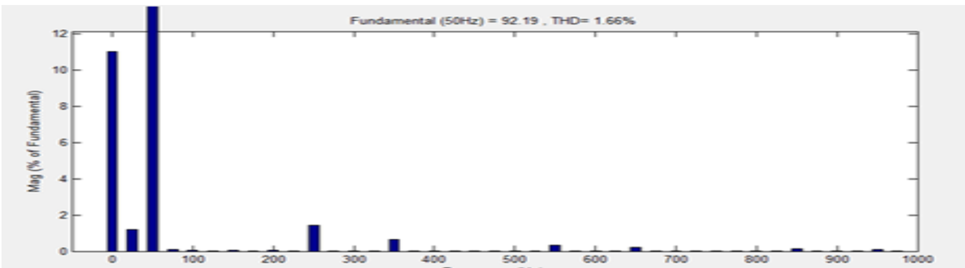

Fig. 15. THD in FFT analysis during irradiation change

V. CONCLUSION

The performance of PQ theory based integrated photovoltaic UPQC is tested.in the normal condition the series VSC provide parts of a reactive power of the load and the proposed PV-UPQC-S mitigating the current quality problems occurring due to disturbance such as a unbalanced loading and change in irradiations. And also the solar PV supplies an amount of active power of the load and this reduces burden on grid. The PV-UPQC-S provides a spotless senergy cohort with improvement in the voltage and current quality

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