Power Quality Improvement of Distribution System with Photovoltaic Energy Conversion System

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ABSTRACT The global trend now is going to renewable energies such as solar and wind power so as to reduce the impact of global warming arising from fossil fuels, but the cost of PV as a distribution Generator (DG) is more expensive than that from the utility grid and also causing harmonics due to the non-linearity of inverter switches.

This paper describe and discussed the PV as (DG) to operate at maximum power point (MPPT) by using two method one of them called perturb and observe (P&O) and the other called Incremental conductance (IC) and the results of both techniques was compared. And also discussed the result of comparison between two level and three level inverter and the direct effect of two inverter topologies in total harmonic distortion (THD) and the control technique using for pulses generator is achieved by voltage oriented control (VOC),At finally The power quality enhancement of on grid photo voltaic DG units is investigated by using the shunt active power filter (SAPF), shunt passive filter (SPF) and by combined between them.in the presence of nonlinear loads that are fed from the PV renewable energy system. The synchronous reference frame (SRF) d-q method is used to calculate the compensating current to drive the purposed (SAPF) of the photovoltaic DG units at the Point of Common Coupling (PCC) on the LV network.

The all system was built and all result was tested in all radiation and temperature by using Simulink/MATLAB.

I. Introduction

the population growth and the rise in the industrial community needs to increasing in the generation energy to continue in their devolvement .The solar energy is commonly used source of energy because a lot of countries located in regions where the sun rising almost time and the solar density my reach up to 1000 w / m ^{2}. the solar energy have exceptional advantages compared with other renewable energy such as dependability, low operation cost due to no fuel cost ,low maintenance cost and noise due to there is no moving parts ,clean and free .However, in other hands there are some disadvantages such as power generated mainly depending on the weather and temperature condition and the cell conversion ranged from 12 to 29 percentage which leads to reduce the maximum power generated [1] .

The PV system divided to three categories stand-alone, grid-connection and hybrid system [2].To overcome the disadvantages of PV system, the maximum Power Point Tracking (MPPT) which defined as technique to extract the maximum power from PV array and treatment the low efficiency of PV system is utilized. [3, 4], by interfacing power electronic devices between the PV and the load [5].There are various type of MPPT methods namely; conventional method or direct method such as perturb &observe method (P&O) and hill clamping method; and the artificial intelligent method such as neural network (NN), fuzzy logic control (FLC) and genetic algorithm .Also Indirect methods such as open circuit voltage (OCV) and short circuit current [6, 7].

In the few last decades the nonlinear load according to devolved in the power electronic is commonly used such as adjustable speed drive (ASD), uninterruptible power supply (UPS), arc Furness, discharge type lamp (fluorescent, sodium vapor, mercury vapor etc.) .that produced harmonics and injected it in the power system so that the utilities grid not be able to provide good power quality to the consumers.. The power quality defined according to (IEEE recommended practice for supervision power quality) as the concept of powering and grounding sensitive equipment in a manner that is suitable for operation of that equipment (IEEE STD 1159-2009). [8].

The power quality also defined from the source side which defined as the ability of the generator to generate power in 50 or 60 HZ while, in the load side defined as maintain the Torrance of voltage variation up to 5%.The total harmonic distortion defined as the ratio between the summation of the power at all harmonics components to the power of the fundamental component and must be reduced under (5%) according to IEEE std.[9,10].The consequences of the harmonic that's causing poor power factor, losses &heating in the transmission line & transformers, reducing in efficiency in rotating machine, thermal stress in cables,.[10, 8].There are many ways to solve and treatment the problems of the harmonics waves like Unified Power Quality Conditioner (UPQC)& filters. there are many types of filters but it classified to two main Categories :

1 Active filter
2-.Passive filter
3- Hybrid filter

The active filter also classified to two sub categories: - 1- Shunt Active Power Filter (SAPF) which used to reduce harmonic current, compensating reactive power and improve the power factor. 2- Series Active Power Filter (SAPF) which used to compensate the problem in the voltage like as sag, swell and unbalanced voltage. The operation idea of the active filter is producing compensating current equal to the harmonic current generated from nonlinear load but opposite in polarity and injected to the system at the point of common coupling (PCC).[11,12]. In this paper the control strategy to produced compensation current will be done by instantaneous power theory which depended on the load current and load voltage that used to improve the total harmonic distortion (THD) and reduce the harmonic in non -linear load. This theory divided to P-Q theory & D-Q theory [11].

the passive filter also classified to two sub categories: shunt passive filter which used to reduce the current harmonics by providing low path impedance of the harmonics and its designed to carry only fractional of current .On the contrary the series passive filter used to reduce the voltage harmonics by providing high path impedance to block the harmonics and its designed to carry full load current and hence it need over current protection [8, 11, 13, 14]..The passive filter more suitable for constant load but it can't filtering the harmonics produced from loads like arc Furness ,motor drives ,wedding equipment.[8,14]

The advantages of passive filter are low cost, simple design, high reliability and easy implementation. The disadvantages of passive filters are large size, fixed compensation, high no-load losses, can't solve the random variations in the load current wave form. In other hands the advantages of the active filters are small size and overcome the transmission losses and resonance and eliminate harmonics up to (20th) order .This paper focused in the design and the control strategy of active filter, and the design of single tuned passive filter.

II. Analysis and modeling of PV simulink

The solar cell consisting of (P- N) junction represented as a thin sheath of semiconductor, the electricity generated when photons collide with the silicon surface, they ionize their atoms, releasing some electrons from them. Thus, some positively charged atoms remain, and the charge can move from one atom to the other freely. This interaction can be simplified by generating electrical energy within the silicon as soon as sunlight hits it [1].The current is collected by electrodes when the electrodes connected to external circuit the current will flow .the PV generation consists of PV cells when these cells are connected in series they lead to increase in voltage, in other hands when these cells are connected in parallel they lead to increase in current. [2]

the PV generator is represented simply by the current source which represents the solar cell is connected in parallel with diode as shown in fig (1)

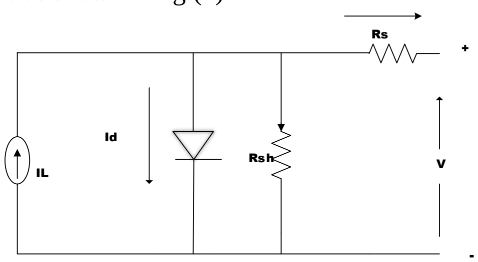

Figure (1): Equivalent Circuit of Solar Cell or PV System

The final equation that represents the circuit of a solar cell is given by [7]

$$I = I_{pv} - I_0[\exp(\frac{V + R_s I}{V_t a}) - 1] - \frac{V + R_s I}{R_p} \quad (1)$$

Where (I_{pv}) represent the PV current, (I_0) represent the PV saturation current, (V_t) the thermal voltage of the array and its equal ($N_s kT/q$) where N_s represent cells connected in series. If the array is composed of Np parallel connections of cells, the PV and saturation currents may be expressed as $I_{pv} = N_p \times I_{pv}$, $I_{pv} = N_p \times I_{pv}$, R_s is the equivalent series resistance of the array and Rp is the equivalent parallel resistance.

In this work the SunPower SPR-305E-WHT-D is used as PV cell for modelling and the characteristics curves are plotting as shown in next figures.

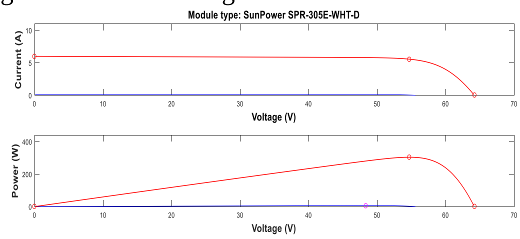

Figure (2): (I-V) & (P-V) curves at temperature 25o c and irradiance 1000w/m2

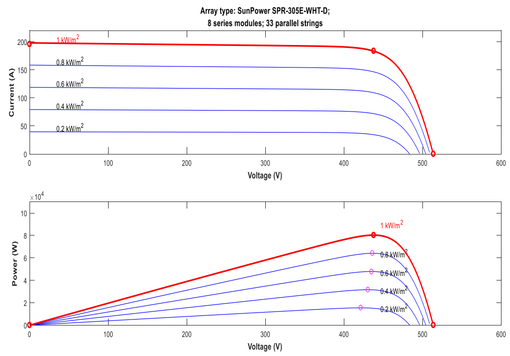

Figure (3): (I-V) & (P-V) curves at temperature 25 c and irradiance (200 400 600 800 1000)

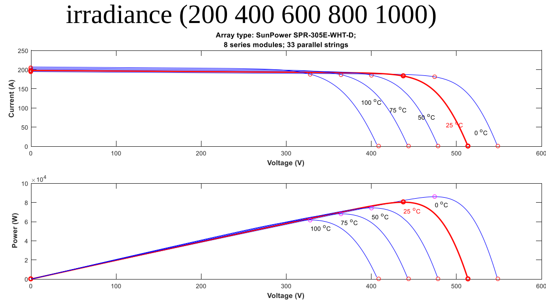

Figure (4): (I-V) & (P-V) curves at irradiance (1000w/m 2) and temperature (0 25 50 75 100 oC)

III. Analysis and modeling of DC-DC converter & MPPT technique& inverter

The most importance disadvantages of PV module as mentioned earlier are high cost and low efficiency so that its importance to operate solar system at MPP under all environmental conditions to make this the DC-DC converter with suitable MPPT technique connected with PV module where the direct connect PV array reach to 31% of its capacity .The job of DC-.DC converter is not limited only to step up the voltage generated from PV system put its play main role to reach to maximum power absorbed from the PV module and its happened by MPPT technique which used to adjust the duty cycle of DC -DC converter where the duty cycle controls the load seen by the source as shown in fig (5).[18,19].

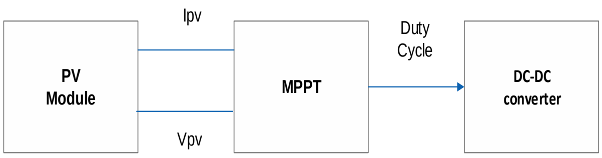

Figure (5) MPPT control block of PV system

Figure (6) shows the equivalent circuit of boost converter which consists of an input inductor (L), controllable switch (S), diode (D), filter capacitance (Co). A coupling capacitor (Ci) is connected between the PV source and the circuit of boost converter to reduce the ripple of the output of PV source. In continuous conduction mode of operation, the circuit has two modes [23] as shown in Fig. (7) as:

a) When the switch is on, the diode is reversed biased, thus isolating the load (Rl). The PV source supplies energy to the inductor.

b) When the switch is off, the load receives energy from the inductor as well as from the PV source.

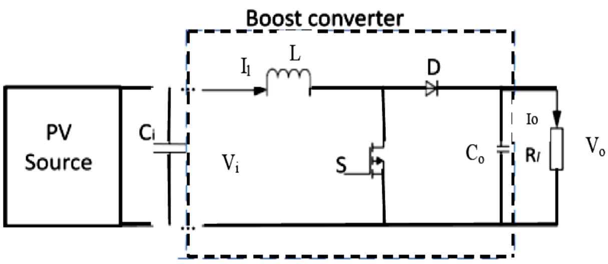

Figure (6): Equivalent circuit of boost converter

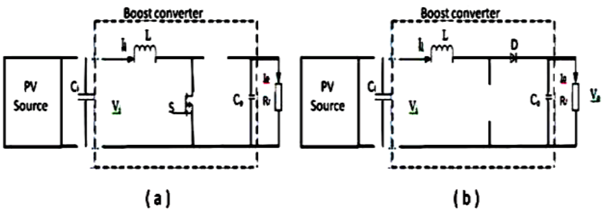

Figure (7): Continuous conduction mode: (a) Switch on (b) Switch of

where (Vo) is the output voltage, Vi is the input voltage from the PV source,(Io) is the output current,(Ii) is the input current and(D) is the duty ratio for the controllable switch. When the inductor current in the boundary edge between continuous and discontinuous conduction modes, the inductance of the boost converter in this case is called the critical inductance Lc which is defined as :-

$$L_c = \frac{R_L D(1-D)^2}{2f_s} \quad (2)$$

Where fs is the switching frequency, RL is the load resistance. So, the value of the required inductor L to ensure that the converter operates in the continuous conduction mode is calculated from [23, 24]:

$$L \geq \frac{D(1-D)V_o}{f_s \Delta I_L} \quad (3)$$

Where ΔIL is the peak-to-peak ripple of the inductor current.

The coupling capacitor Ci between the PV module and boost converter is calculated such that the ripple of PV output current must be less than 4 % of its mean value [24]:

$$C_i \geq \frac{I_o D^2}{0.04(1-D)V_i f_s} \quad (4)$$

The output capacitor C_o value calculated to give the desired peak-to-peak output voltage ripple is defined as [23]:

$$C_o \geq \frac{V_o D}{\Delta V_o R_L f_s} \quad (5)$$

Where ΔVo is the peak-to-peak ripple of the output voltage.

There is an only one optimum value of the resistance that matchs with the MPP of the PV module. If the load resistance deviates from the optimum value, the intersection point departs from MPP.

$$R_{opt} = \frac{V_{MPP}}{I_{MPP}} \quad (6)$$

Average output voltage is given by:

$$V_o = \frac{V_i}{1-D} \quad (7)$$

Assuming the conversion efficiency of the converter is 100%, the relationship between the output current (I_o) and the input current (I_i) can be written as

$$\frac{I_o}{I_i} = \frac{V_i}{V_o} = 1-D \quad (8)$$

Then,

$$I_o = (1-D)I_i \quad (9)$$

From equations (8) and (9), the relation between the input resistance seen by PV module (R_{equav}) and the output load impedance (R_L) can be described using the following equitation

$$R_{equav} = \frac{V_{in}}{I_{in}} = \frac{(1-d)V_{out}}{\frac{I_{out}}{1-D}} = (1-D)^2 \frac{V_{out}}{I_{out}} = (1-D)^2 R_{load} \quad (10)$$

$$D = 1 - \sqrt{\frac{R_{equiv}}{R_{load}}} \quad (11)$$

The equivalent resistance of the PV module (R_{equiv}) is seen as input resistance of the converter. By changing the duty cycle (D), the value of Requiv can be equated to that of optimal resistance R□□□. Therefore, the load resistance RL can be anything (static or dynamic) as long as the duty cycle is adjusted accordingly.

In this paper the study of MPPT well be done by two method:-

A. *Perturb and Observe*

This method is commonly used because it is easy and suitable for low cost application and it is also called Hill Clamping because it's trying to clamping the power curve. [19]

This method is operating by watching the change in the output voltage of PV module increasing or decreasing (ΔV) and observe the effect of this changing in the result power, then compared the new power (Pn) with the previous power (P (n-1)) and from this Comparison it can be determined if there is a need to increase or decrease on the voltage (ΔV).The next table (1) and flow chart in fig (8) explain how this method worked [19]

Table [1]: P&O method steps

Change in voltage	Change in power	Next step
Positive	Positive	Positive
Positive	negative	negative
Negative	Positive	negative
Negative	negative	Positive

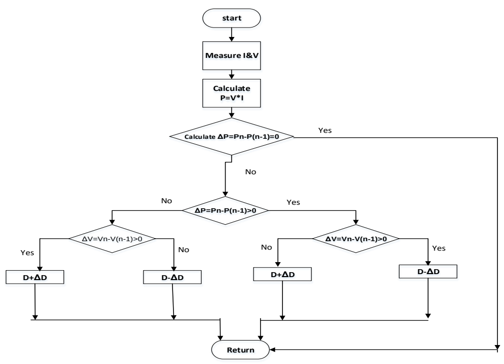

Figure (8): Flow chart of P&O method for MPPT

B. *Incremental Conductance (IC) MPP Tracking Method*

This method depend on the (P&O) principals and overcome the disadvantages of it such as high steady state error because the operation point have low disturbance. [18] .The principal idea depend on the slope of (P-V) curve of PV module (ΔP/ΔV) where the MPP occurred at this slope equal zero ,positive in left side ,negative in right side [20].The next flow chart in fig (9) discusses the operation of (IC) method . At the first the present voltage and current value will be measured and compared with the previous value to calculate the variation in the power (ΔP) [20] .Where if (ΔP>0) the perturb process is continuous and its flow in the same direction otherwise it will move in reverse direction it will move in reverse direction [21].

$$\frac{dP}{dv} = \frac{d(V \times I)}{dV} = I \times \frac{dV}{dv} + V \times \frac{dI}{dV} = I + \frac{dI}{dV} \quad (12)$$

$$\frac{dP}{dI} = \frac{d(V \times I)}{dI} = I \times \frac{dV}{dI} + V \times \frac{dI}{dI} = V + \frac{dV}{dI} \quad (13)$$

From equation (12, 13) if:-

(1) $\frac{dI}{dV} = -\frac{I}{V}$ The operating point lies in MPP

(2) $\frac{dI}{dV} > -\frac{I}{V}$ The operating point lies in left of MPP

(3) $\frac{dI}{dV} < -\frac{I}{V}$ The operating point lies in right of MPP

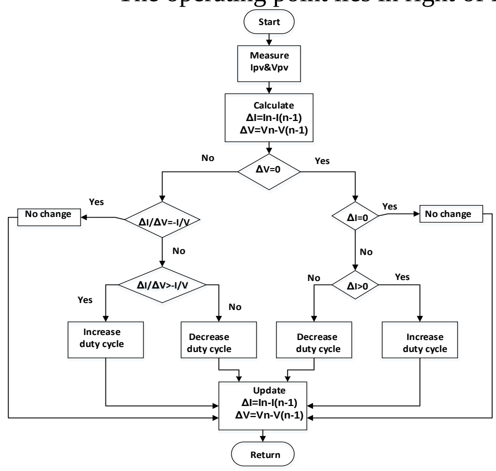

Figure (9): Flow chart of IC MPP Tracking Method

IV. *PV- grid connected Inverter*

There is many different techniques can be used to control the grid connected inverter such as direct power control (DPC), virtual flux direct power control (VFDC) and voltage oriented control (VOC).

In this thesis VOC is utilized because it have some advantages as [25]

1- Fixed switching frequency.

2- Low sampling frequency for good performance.

This method depends on the transformation from three phase stationary reference system (a b c) to two phase stationary reference system(α β)and then transformed to asynchronous rotating reference system (d q). These transformation guarantees that the control voltage remains constant and becomes DC value and making the process simple.

At the first assuming that the grid voltage Vag, Vbg, Vcg then the transformation from (a b c) frame to (α β) by using Clark transformation from next expression [26]:

$$\begin{pmatrix}\alpha\\ \beta\end{pmatrix}=\begin{pmatrix}\frac{2}{3} & \frac{-1}{3} & \frac{-1}{3}\\ 1 & -\frac{1}{2} & -\frac{1}{2}\end{pmatrix}\begin{pmatrix}a\\ b\\ c\end{pmatrix} \qquad (14)$$

Finally the transformation from (α β) coordinate to (d q) coordinate shown in the next expression by using Park transformation

$$\begin{pmatrix}d\\ q\end{pmatrix}=\begin{pmatrix}\cos\theta & \sin\theta\\ -\sin\theta & \cos\theta\end{pmatrix}\begin{pmatrix}\alpha\\ \beta\end{pmatrix} \qquad (15)$$

The line voltage V_{abc} needs to feed the phase locked loop (PLL) and the voltage angle (θ) is used for transformation from 3 phase system to dq coordinate for line voltage and current. The dq coordinate value and DC link voltage are used in decoupled control. Finally the reference voltage created by the controller are sent to (PWM) to create the switching patterns S_{abc} .The following equation and fig (10) express the above description

$$I^*_{dg}=[V^*_{dc}-V^{meas}_{dc}]*[K^{dc}_p+\frac{K^{dc}_i}{S}] \qquad (16)$$

$$V_{dPWM}=[I^*_{dg}-I_{dg}]*[K^i_p+\frac{K^I_i}{S}] \qquad (17)$$

$$I^*_{qg}=[Q_g-Q^{meas}_g]*[K^Q_p+\frac{K^Q_i}{S}] \qquad (18)$$

$$V_{qPWM}=[I^*_{qg}-I_{qg}]*[K^i_p+\frac{K^I_i}{S}]+R_f I_{qg}+W_g L_f I_{dg}+V_{qg} \qquad (19)$$

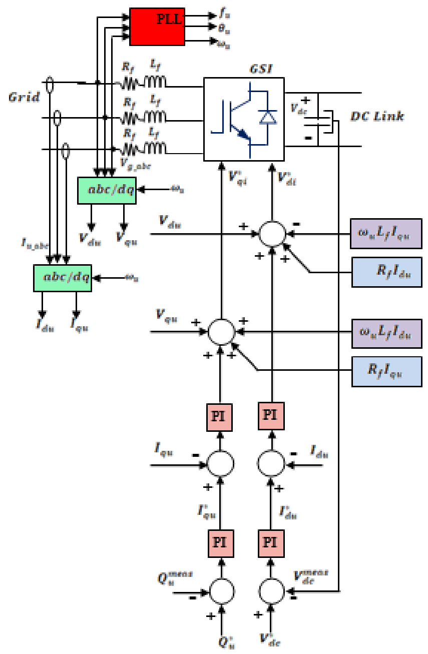

Figure (10): Control circuit of PV-grid connected Inverter

V. Analysis and modeling of Active &Passive power filter

The active and passive filter used to improve the power quality of distribution system with PV system are designed in the following sections

A. The active filter design

The active filters are divided to two categories, The series active filter & shunt active filter which used to improvement in voltage and current quality respectively .In this work shunt active filter is used to eliminate the harmonic current produced by non - linear load which represented by six pulses control rectifier connected to R-L load as shown in fig (11).. The compensating current produced from (VSI) which consist of six -pulses bridge and inject these current in (PCC) throw interfacing inductor (Lf),. The main principle of APF control strategy produces gate signal used to switch the (IGBT) switches in (VSI) based on variation on load voltage and load current [12].

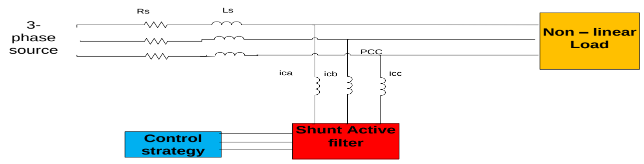

Figure (11): Power system with non-linear and shunt active filter

B. *Active power filter control strategy*

In the instantaneous active and reactive power theory with (d-q)technique which also called synchronous reference frame [15] the fundamental current converted to (DC) component and other unwanted (ac) frequency component .,These two component can be passed throw low pass filter (L P F) and then Subtraction the total P(ac + dc) from the output of (L P F)[9]as show in fig(12).

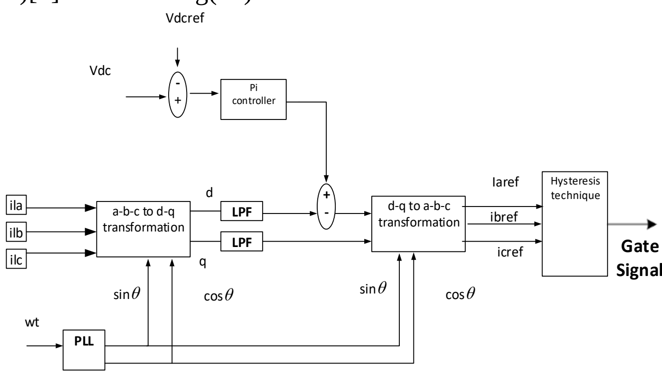

Figure (12) Active filter Control Strategy

This simplest strategy acts by transforming the (a-b-c) axis which called the three phase reference frame to two vertical axis so called orthogonal stationary reference frame (α-β) by using Clark transformation. These axis transformed (d-q-0) axis which called rotating coordinate by using park transformation which transfer again to (α-β)by using inverse park transformation [1].Finally after this operation this component will be transferred again to (a- b - c) by using inverse (d-q) transformation [12,15] as shown it is represented by equation (20-25) ..The output waves from the last transformation called reference current will going to the hysteresis current control which produced pulses to (IGBT) switches in (VSI) to produce the compensating current. .The next equation explain this method [16, 17]:

$$\begin{pmatrix} i_0 \\ i_\alpha \\ i_\beta \end{pmatrix} = \sqrt{\frac{2}{3}} \begin{pmatrix} \frac{1}{\sqrt{2}} & \frac{1}{\sqrt{2}} & \frac{1}{\sqrt{2}} \\ 1 & -\frac{1}{2} & -\frac{1}{2} \\ 0 & \frac{\sqrt{3}}{2} & -\frac{\sqrt{3}}{2} \end{pmatrix} \begin{pmatrix} i_{La} \\ i_{Lb} \\ i_{Lc} \end{pmatrix} \quad (20)$$

$$\begin{pmatrix} I_{ld} \\ I_{lq} \end{pmatrix} = \begin{pmatrix} \cos\theta & \sin\theta \\ -\sin\theta & \cos\theta \end{pmatrix} \begin{pmatrix} I_{l\alpha} \\ I_{l\beta} \end{pmatrix} \quad (21)$$

$$id = iddc + idac \quad (22)$$

$$iq = iqdc + iqa \quad (23)$$

$$\begin{pmatrix} i_{\alpha ref} \\ i_{\beta ref} \end{pmatrix} = \begin{pmatrix} \cos(\omega t) & -\sin(\omega t) \\ \sin(\omega t) & \cos(\omega t) \end{pmatrix} \begin{pmatrix} i_{dac} \\ i_{qac} \end{pmatrix} \quad (24)$$

$$\begin{pmatrix} i_{aref} \\ i_{bref} \\ i_{cref} \end{pmatrix} = \sqrt{\frac{2}{3}} \begin{pmatrix} \frac{1}{\sqrt{2}} & 1 & 0 \\ \frac{1}{\sqrt{2}} & \frac{-1}{2} & \frac{-1}{2} \\ \frac{1}{\sqrt{2}} & \frac{\sqrt{3}}{2} & \frac{-\sqrt{3}}{2} \end{pmatrix} \begin{pmatrix} i_{0ref} \\ i_{\alpha ref} \\ i_{\beta ref} \end{pmatrix} \quad (25)$$

C. Hysteresis current control

The voltage source inverter (VSI) having three legs each leg containing two switches which is controlled by gate signals. There are many technique to control the compensating current produced from the inverter such as PWM technique and hysteresis technique. The advantages of the last one is: -fast transient response, simple implementation and high accuracy [2]. In this technique if the Comparison voltage equal to or more than the threshold voltage level it will generate positive gate signal .In other hand it will be generate negative gate signal if it less than the threshold voltage level [12].

D. *Design of shunt passive filter*

The passive filter in generally consist of passive element such as resistance, induction and capacitance. There are many types of shunt passive filter like single tuned, double tuned, triple tuned, quadruple tuned, and high pass damped filters. The single tuned passive filter (STPF) is Widely spread because the simple design and lower cost where its consist of resistance(R) ,inductance(L) ,capacitance(C) connected in series as shown in fig (13),.It can be tuned to cancel the lower order of harmonic like (3th,5th,7th...).[8]. .This type of filter may be work as high-cut filter or pass-band filter. [10].

The design of (STPF) parameter calculated from the next equations:

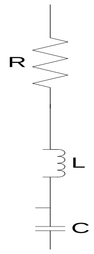

Figure (13): Shunt passive filter

1-The value of capacitive reactance can be calculated as

$$X_c = \frac{V_s^2}{Q_c} \quad (26)$$

Where Vs is the nominal voltage source and Qc is reactive power of the system

2- The value of capacitance can be determined as:

$$C = \frac{1}{2 \times \pi \times Fc \times Xc} \quad (27)$$

3- To calculate the nth harmonics the value of inductance will be:

$$L = \frac{1}{(2 \times \pi \times Fc \times n)^2 \times C} \quad (28)$$

Where n represent the order of harmonic

4-The value of resistance for the filter is:

$$R = \frac{\sqrt{L/C}}{Q} \quad (29)$$

Where Q represent the quality factor and it's ranged between 30<Q<100 [10].

VI. Simulation Results

The following table shows the total harmonic distortion THD value at two level and three level inverters

temperature	irradiance	THD at two level inverter	THD at three level inverter
25	100	97.65%	41.35%
25	200	40.97%	19.74%
25	300	26.9%	12.76%
25	400	20.97%	9.54%
25	500	16.22%	7.41%
25	600	13.63%	6.26%
25	700	11.84%	5.33%
25	800	10.12%	4.77%
25	900	9.32%	4.15%
25	1000	8.25%	3.81%
50	1000	8.93%	4.08%

Table (2)

From this table the THD decrease by increasing the inverter level.

The next figures shows the MPPT by using two technique of MPPT (P&O) and (IC)

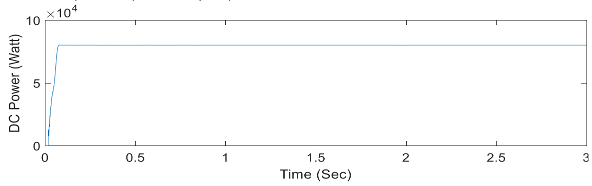

Figure (14) Dc power of PV extracted from P&O technique

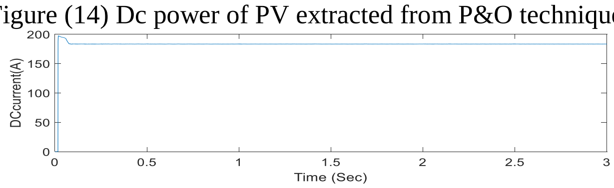

Figure (15) Dc current of PV extracted from P&O technique

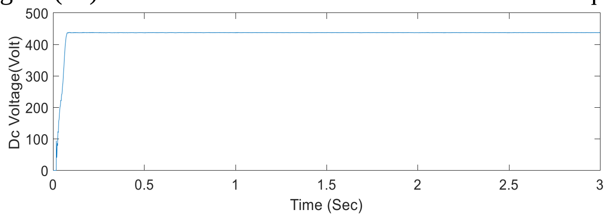

Figure (16) Dc voltage of PV extracted from P&O technique

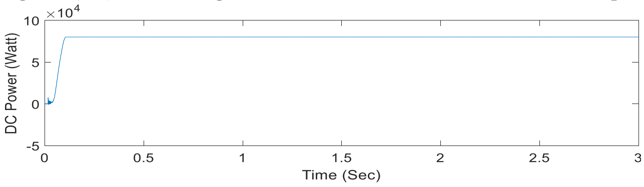

Figure (17) Dc power of PV extracted from IC technique

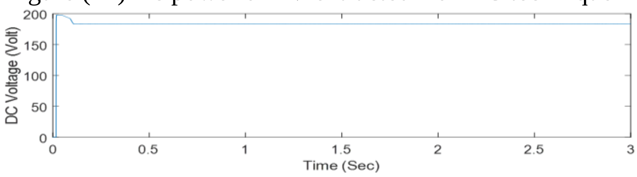

Figure (18) Dc current of PV extracted from IC technique

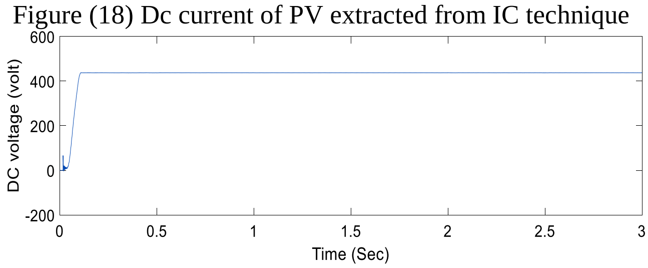

Figure (19) Dc voltage of PV extracted from IC technique

The next figures describe the THD without filters, by using passive filter, active filter and combined between active filter and passive filters.

.At the first case without filters the total harmonic distortion is 29.78%,when using passive filter the total harmonic distortion reach to 25.27%,and when using active filter the total harmonic distortion reach to6.3% at the last when using the active and passive filters the total harmonic distortion decreases to 5.36%. This result discuses when the irradiance of PV system equal (1000 w/m 2) and the temperature (25ºc) when using three level inverter.

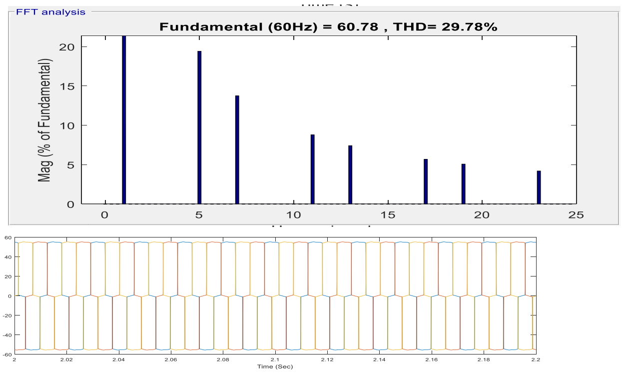

Figure (20) THD without filters

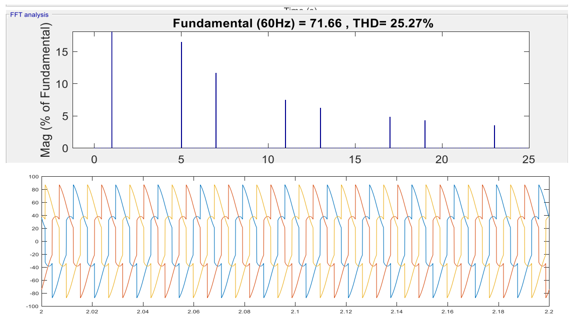

Figure (21) THD with passive filter

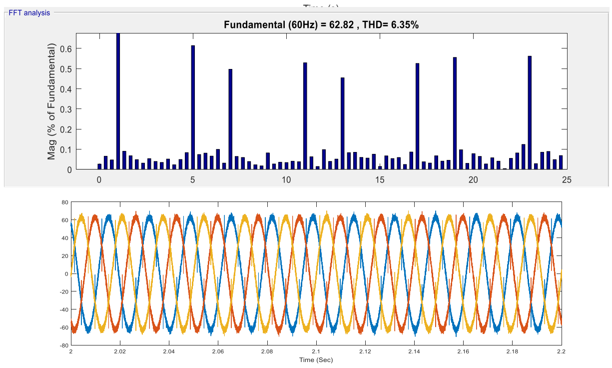

Figure (22) THD with active filter

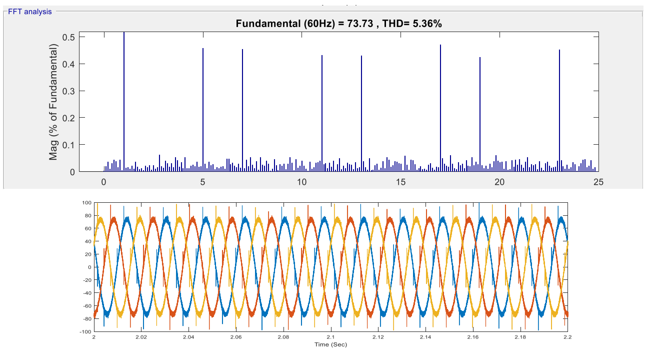

Figure (23) THD with AF & PF

5.1-Study the effect of changing load

Case (1) at increasing load

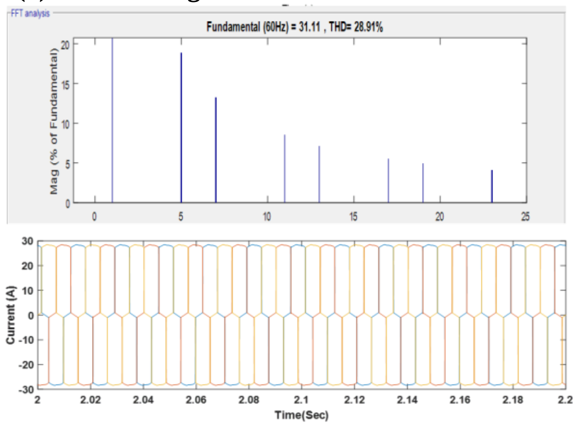

Figure (24) THD without filters

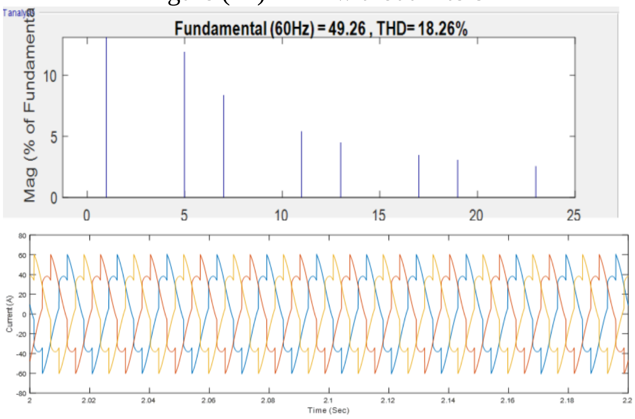

Figure (25) THD with Passive Filter

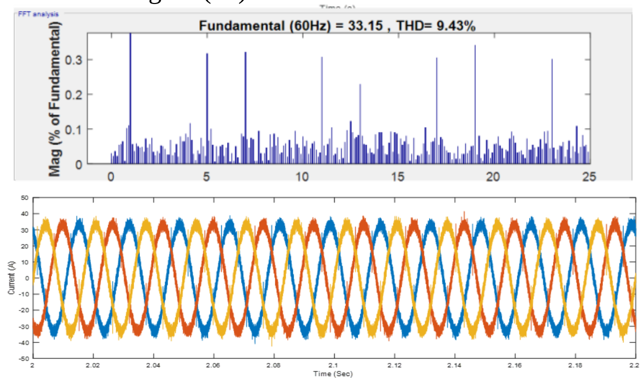

Figure (26) THD with Active Filter

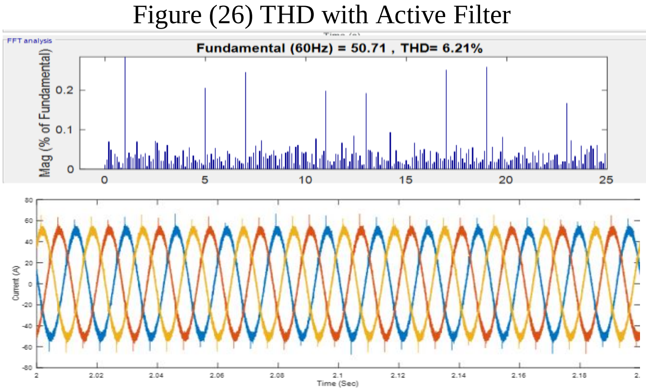

Figure (27) THD with active & passive filter

Case (2) at load decreasing

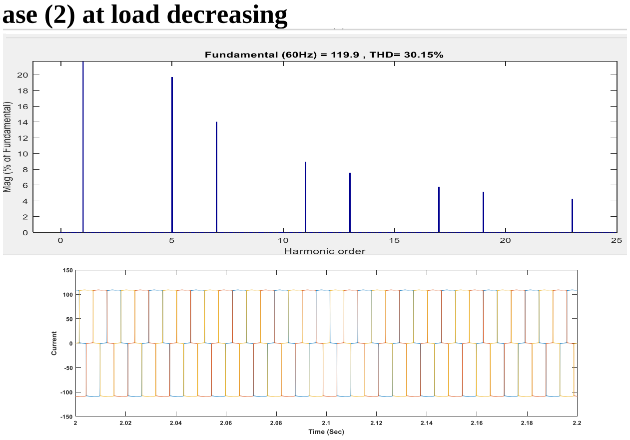

Figure (28) without filters

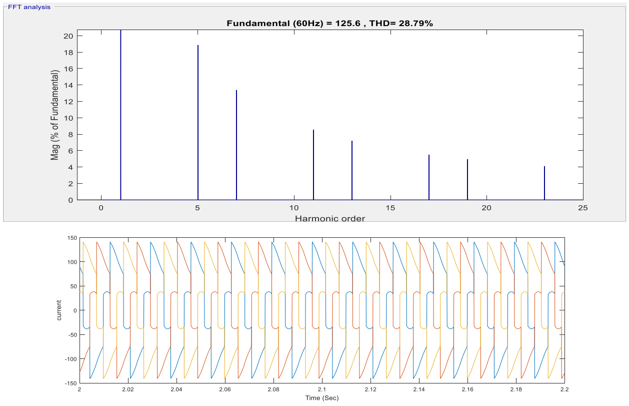

Figure (29) with passive filter

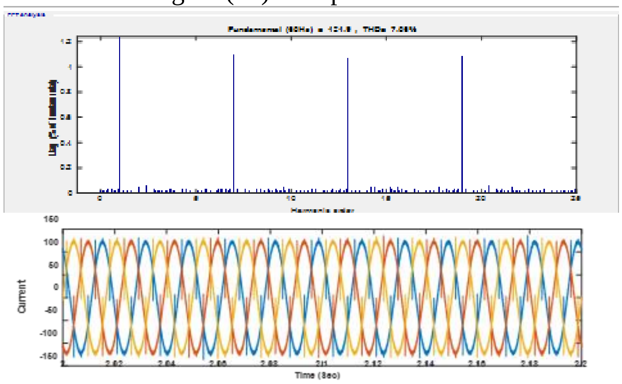

Figure (30) with Active filter

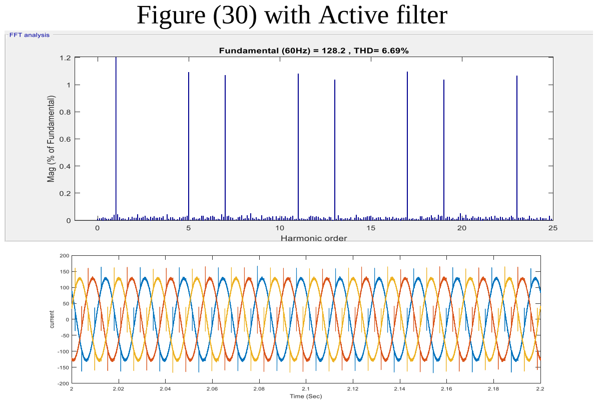

Figure (31) with active & passive filter

The next table (3) explains the effect of changing load in THD

Load	Without filters	With passive filter	With active filter	With both active & passive
10Ω +90 mh	29.78%	25.27%	6.3%	5.36%
5 Ω +45 mh	30.15%	28.79%	7.08%	6.69%
20 Ω +180 mh	28.29%	18.26%	9.43%	6.21%

VII. Conclusion

Distributed PV system supplies nonlinear load with active filter has been analyzed and simulated in MATLAB/SIMULINK. Two techniques of MPPT has been used to extract the maximum power from PV system. Moreover, two topologies of grid connected inverter for PV system have been applied and compared. It can be approved that the total harmonic distortion (THD) of output current is decreasing with increasing the solar irradiance and temperature, .Furthermore the nonlinear load has been connected to PV system with active filter to suppress the harmonic caused by this load. The THD has been decreased from 29.78 % to25.27% with only passive filter, Also it decreases from 29.78% to 6.3 %with only active filter and from 29.78 % t0 5.36 % with both active filter and passive filter.

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