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Improvement of Power Quality by using Advanced Reactive Power Compensation

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ABSTRACT

A particle swarm optimization (PSO) algorithm was used to automatically find the parameters and improve the performance of the controller. The terminal voltage, current and corresponding duty-cycle, at which the DC/DC converter should be switched to obtain maximum power output, is determined. It is observed from the results that the particle swarm optimization based algorithm can track the maximum power point for the whole range of solar data (irradiance and temperature) and has high conversion performance. The system was simulated and tested in the MATLAB/Simulink environment, the PSO algorithm was run in the m-file and the system was simulated hundreds of times to achieve the best results presented in this paper. This article introduced the most common techniques for PV systems to monitor MPP.

KEYWORDS: *Photovoltaic System (PV) ,PSO, DC-DC Converters, Micro-Grid (MG)*

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INTRODUCTION

Due to the critical condition of industrial fuels which include oil, gas and others, the development of renewable energy sources is continuously improving. This is the reason why renewable energy sources have become more important these days. Few other reasons include advantage slike abundant availability in nature, eco-friendly and recyclable. Many renewable energy sources like solar, wind, and tidal are there. Among these renewable sources solar and wind energy are the world's fastest growing energy resources. With no emission of pollutants, energy conversions did through wind and PV cells. Day by day, the demand for electricity is rapidly increasing. But the available base load plants are not able to supply electricity as per demand. So these energy sources can be used to bridge the gap between supply and demand during peak loads[1]. This kind of small scale stand-alone power generating systems can also be used in remote areas where conventional power generation is impractical. In this dissertation, a wind-photovoltaic hybrid power generation system model is studied and simulated. A hybrid system is more advantageous as individual power generation system is not completely reliable. When any one of the system is shutdown the other can supply power [2]. A block diagram of entire hybrid system is shown below.

Grid connected Solar PV array with STATCOM:

The solar PV panel system can be formed through parallel and series integration of the different solar PV panels. The series connection of the solar PV panel will increase the solar PV panel array terminal voltage, and the parallel connection of the solar PV panel array will increase the solar PV panel array current rating. The rating of the single panel is 213.15 W, maximum power point PV panel voltage is 29 V, PV panel voltage at the open circuit is 36.3 V, PV current at the short circuit is 7.84 A, and maximum power point cutter is 7.35 A. series-connected PV panel is 10, and parallel-connected PV panel is 47. The overall rating of the solar PV array is 100.345 kW, PV panel voltage at the open circuit is 363 V, PV current at the short circuit is 368.48 A, maximum power point current is 345.45 A, and maximum power point voltage is 290 v. The solar PV array has maximum power is 9.72 kW at 100 W/m2 and 25°C, maximum power is 50.75 kW at 500 W/m2 and 25°C and maximum power is 100.345 kW at 1000 W/m2 and 25°C. The PV and VI characteristics have been shown in fig- 4 and fig-3 respectively.

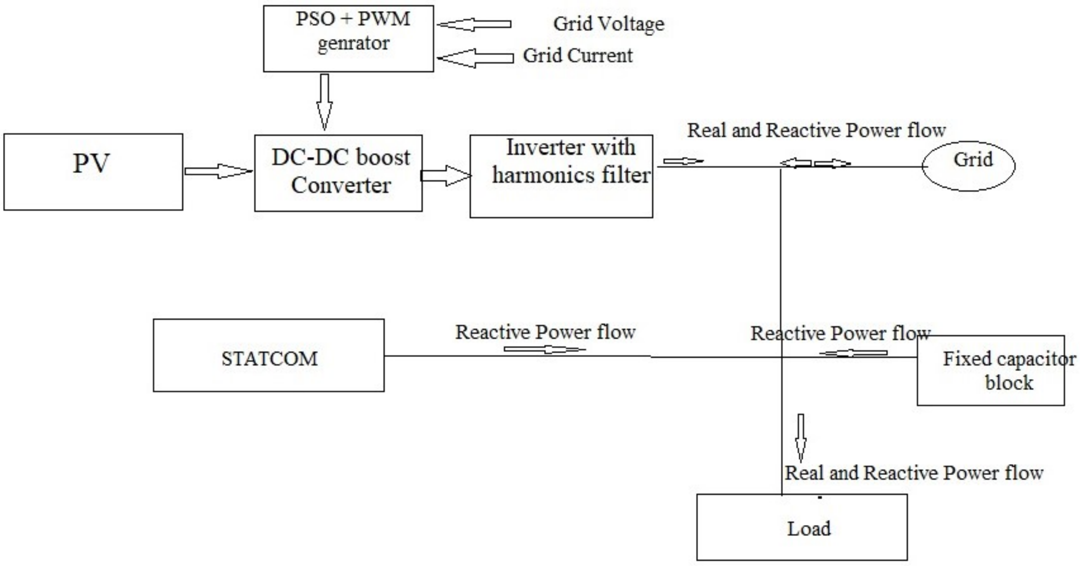

Fig-1 Block diagram of proposed solar system

PSO algorithm:

Particle optimization (PSO) is one of the concepts of swarm intelligence [3], inspired by research in neuroscience, cognitive psychology, social behavior, and behavioral science and introduced into the field of computer science and artificial intelligence [4] as an innovation, collective and distributed intelligence paradigm for problem solving, primarily in the field of optimization, without the need for centralized management or the provision of a global model [5,6]. When using PSO with a multivariable optimization problem, the population takes on specified sizes corresponding to the variables of the objective function. In the multidimensional design space, particles are individually placed in initial random positions with zero velocity. The population of particles represents the speed of searching for possible solutions with positions and velocities [7].

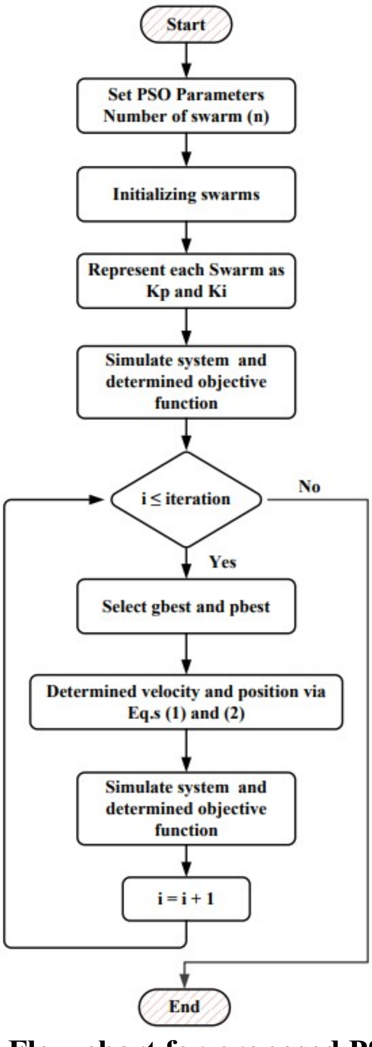

Fig-2 Flow chart for proposed PSO method

The PSO algorithm is considered one of the best optimization techniques and is superior to other optimization techniques in terms of ease of implementation, robustness, and ability to converge globally. For these reasons, the PSO algorithm was chosen for this paper. In this way, we can check the convergence of the algorithm and find the optimal value of the objective function [18-19]. The principle of the PSO algorithm depends on its two factors: speed and position. Members represent these updated factors using formulas (1) (2).Figure 2 shows the flowchart of the proposed optimization procedure.

$$V_i^d(t+1)=wV_i^d(t)+c_1r_1\left(P_t^d(t)-X_i^d(t)\right)+c_2r_2\left(P_t^d(t)-X_i^d(t)\right) \quad (1)$$

$$X_t^d(t+1)=X_i^d(t)+V_i^d(t+1) \quad (2)$$

Where, $c1$ is social rate and $c2$ is cognitive rate. $r1$ and $r2$ is the random interval (0,1). V is the velocity w is the inertia factor. X is the Position factor.

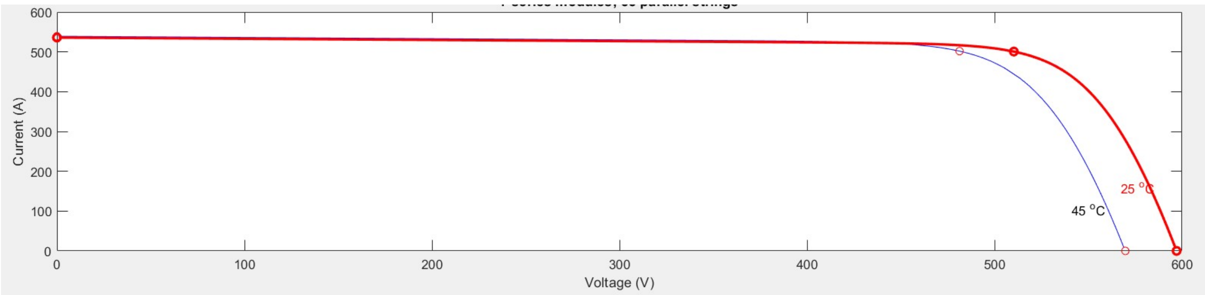

Fig-3 V_I Charecteristics of solar array

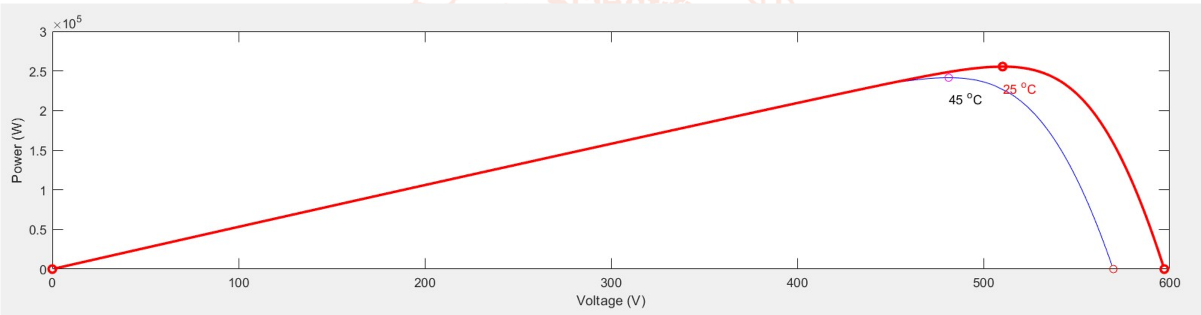

Fig-4 P_V Charecteristics of solar array

Shunt Compensation:

In shunt compensation, the power system is connected in parallel (parallel) to the FACTS. This acts as controllable current source shunt balancing as shown in figure (5). There are two types of shunt compensation. The shunt capacitance is used to improve the power factor. If the load connected to the line is lagging, shunt capacitance compensation is most often used, since commonly used loads are inductive in nature. Shunt inductance compensation is used in long transmission lines where the Ferranti effect occurs because the voltage capacitance at the receiving end of the transmission line increases. As the inductance is shifted, the transfer capacitance increases. It is obvious that the required power can be supplied by controlling the angle of the thyristor connected to the power line according to the required power and thus alternating current can be supplied to the transmission line. You can control the current injected into series compensation and control the voltage injected into parallel compensation STATCOM and D-STATCOM FACTS technology is an application of power electronics in transmission line systems. The main purpose of this technology is to control and regulate electrical variables such as (current, voltage, impedance) to effectively compensate voltage drops in power systems. Rapid advances in power electronics technology are increasingly expanding the use of power electronics devices at various voltage levels in electrical power systems. STATCOM is one such device that could potentially be used in case of its transmission level FACTS and distribution level power limit controller as well as in end user electrical installations. Potential related applications include voltage regulation, power factor correction, load sharing, and harmonic reduction. DSTATCOM is a voltage converter (VSC) based power electronics device. This device is normally backed up by energy temporarily stored in a DC capacitor. The DSTATCOM filters the load current to meet the grid connection specifications.

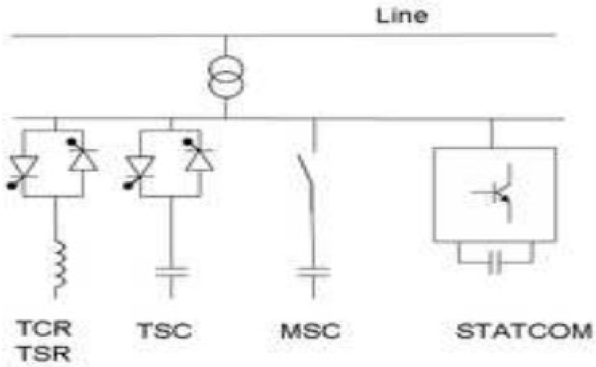

Fig 5-Shunt compensation

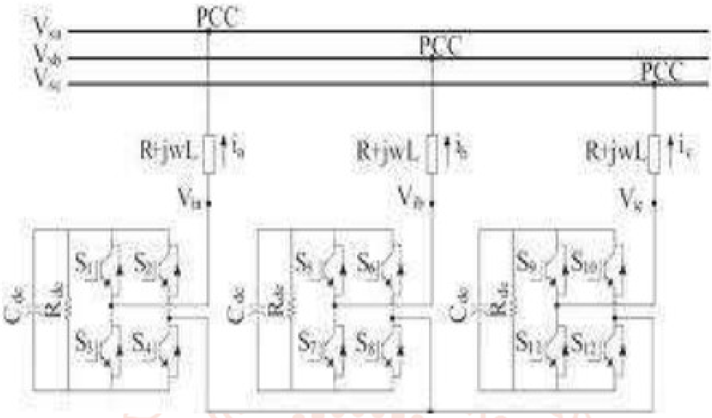

Fig-6 STATCOM used for power injecting in three phase transmission line

The voltage to inject in the transmission line in each phase:

$$P_s = P_r = \text{V Cos}\,(\delta/2) * \frac{2V\ Sin\ (\delta/2)}{X} = \frac{V^2}{X}\ \text{Sin}(\delta/2) \qquad (3)$$

$$Q_s = -Q_r = \text{V Sin}\,(\delta/2) * \frac{2V\ Sin\ (\delta/2)}{X} = \frac{V^2}{X} * (1 - Cos\ (\delta)) \qquad (4)$$

These two equations describe the flow of active and reactive power in a transmission line. Both powers also depend on line reactance and power factor. Therefore, it can be controlled by reducing the influence of the inductance of the transmission line.

Result: To justify our aim MATLAB results have been shown in Fig-7 – 15.

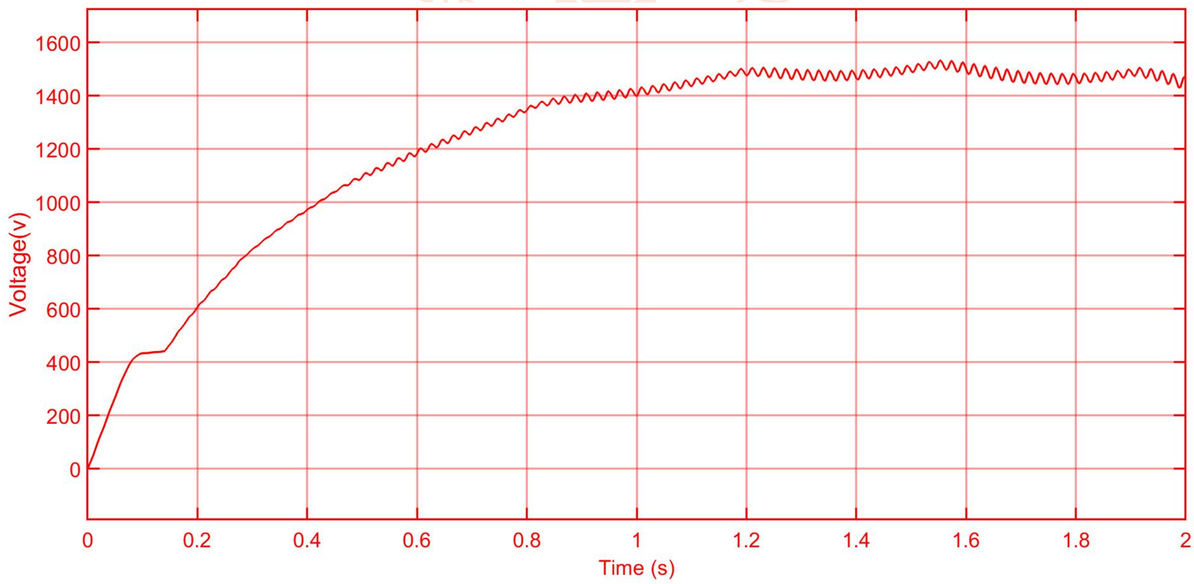

Fig-7 Solar Voltage (With STATCOM and PSO algorithm)

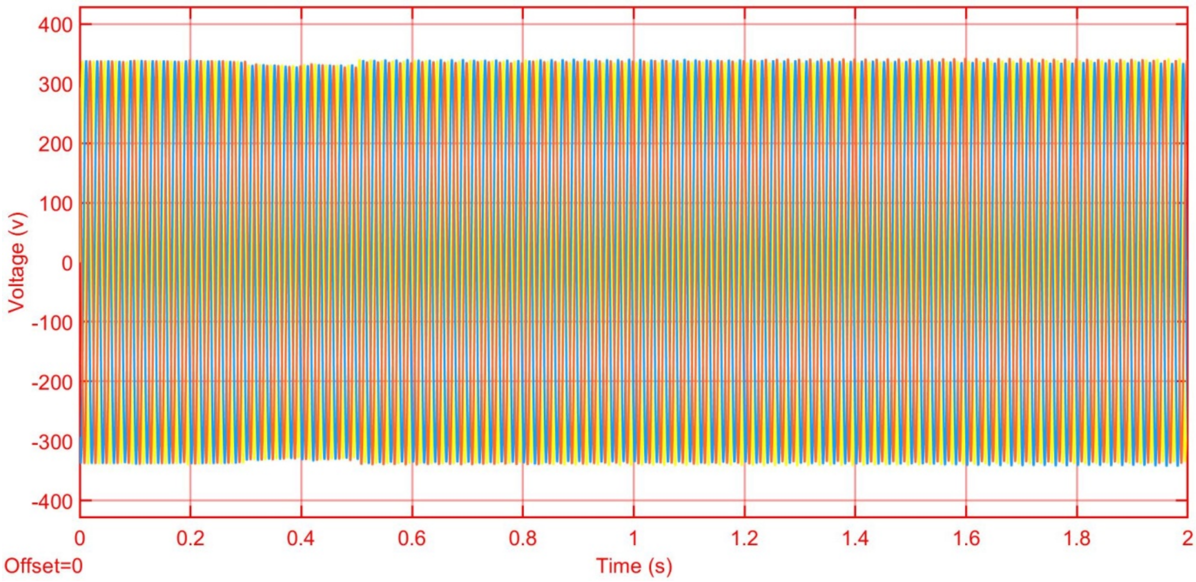

Fig-8 Grid Voltage (With STATCOM and PSO algorithm)

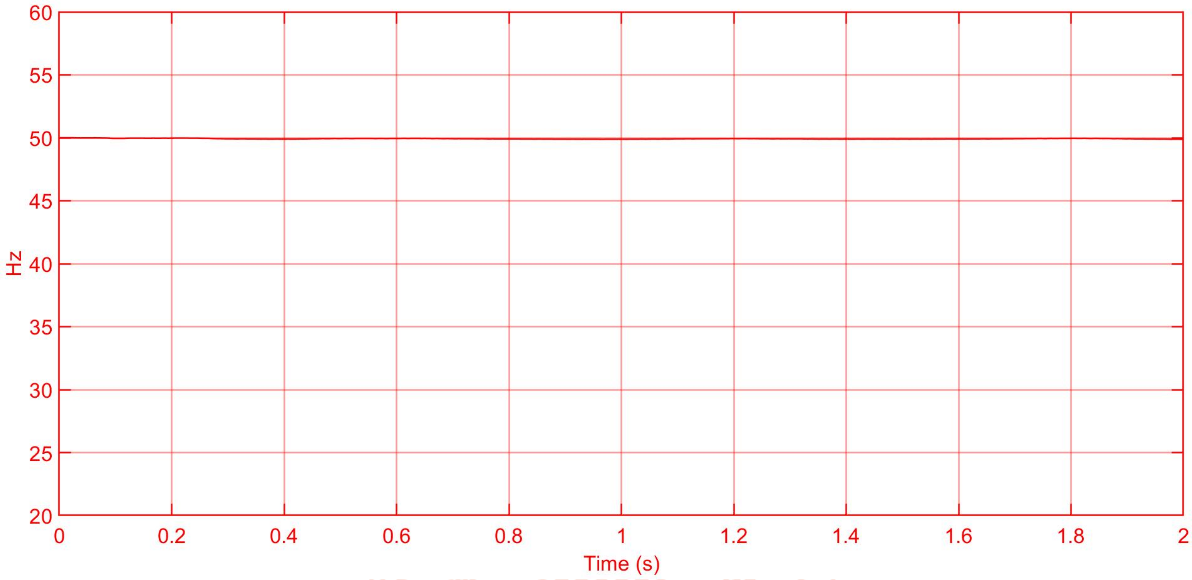

Fig-9 Frequency of grid (With STATCOM and PSO algorithm)

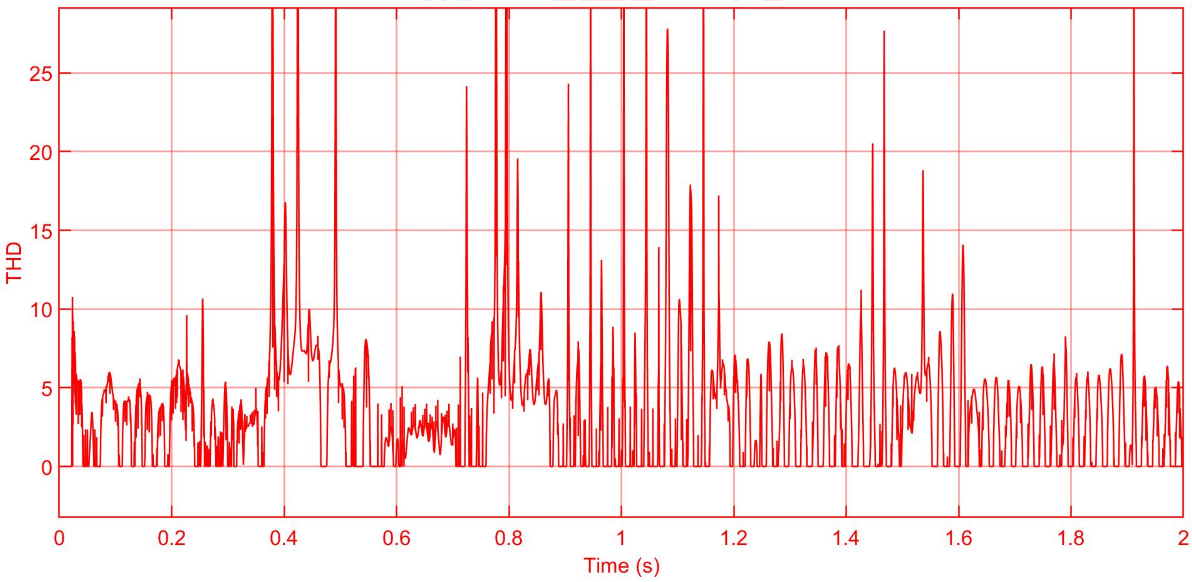

Fig-10 THD (With STATCOM and PSO algorithm)

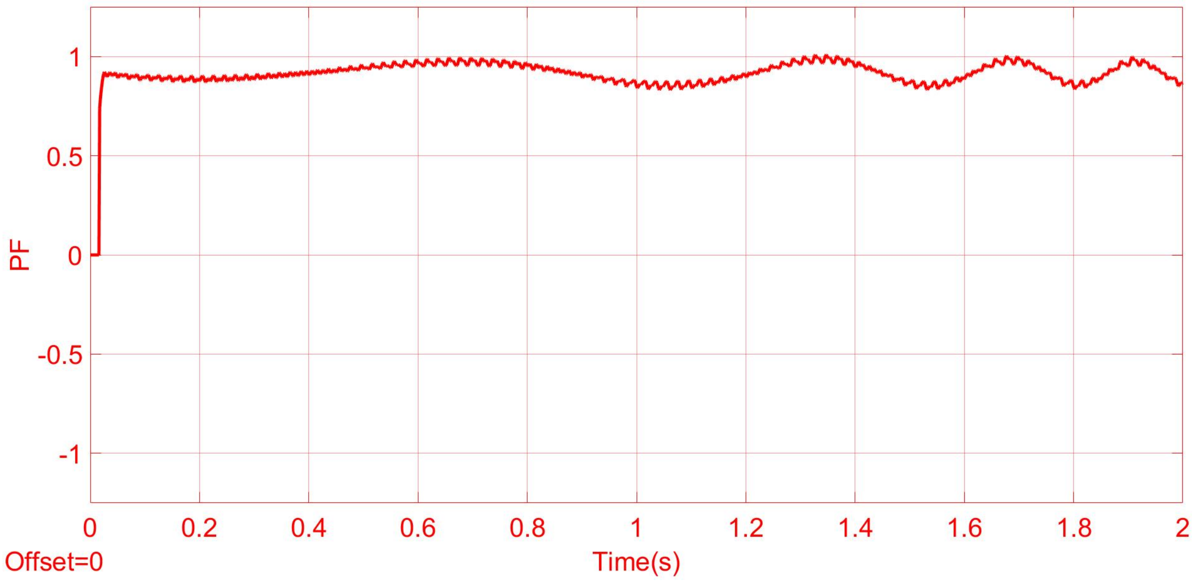

Fig-11 Power Factor (With STATCOM and PSO algorithm)

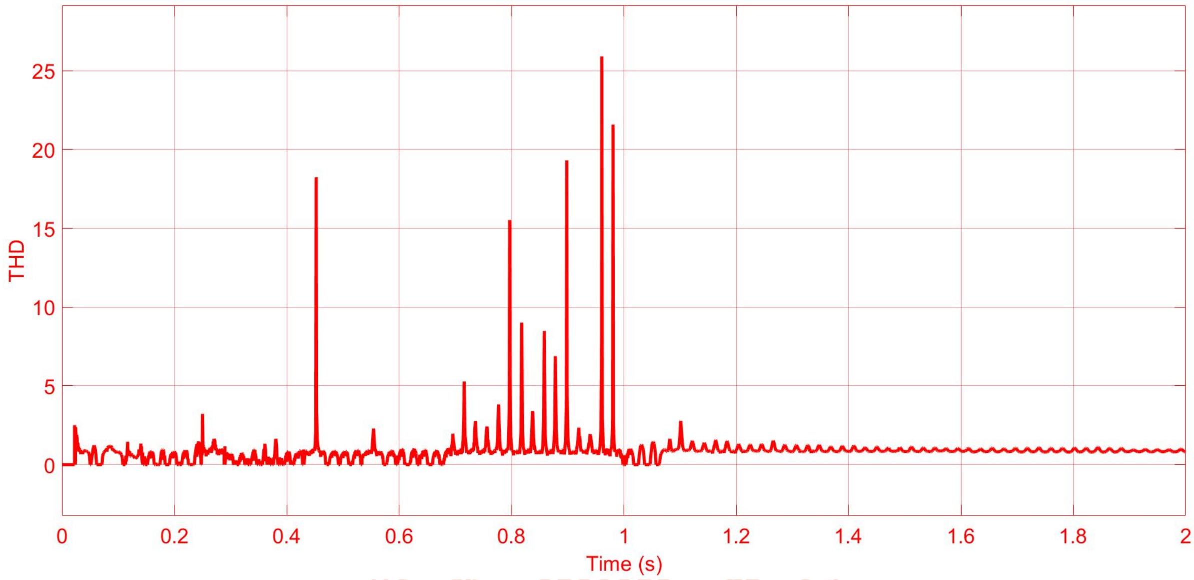

Fig-12 THD(Without STATCOM and PSO algorithm)

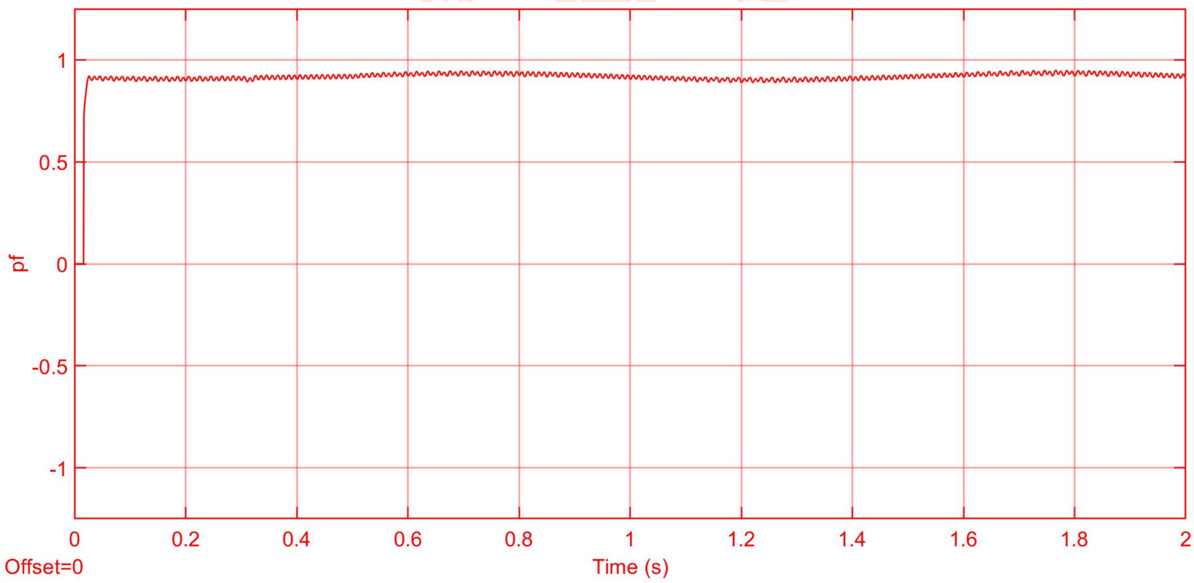

Fig- 13 Power Factor (Without STATCOM and PSO algorithm)

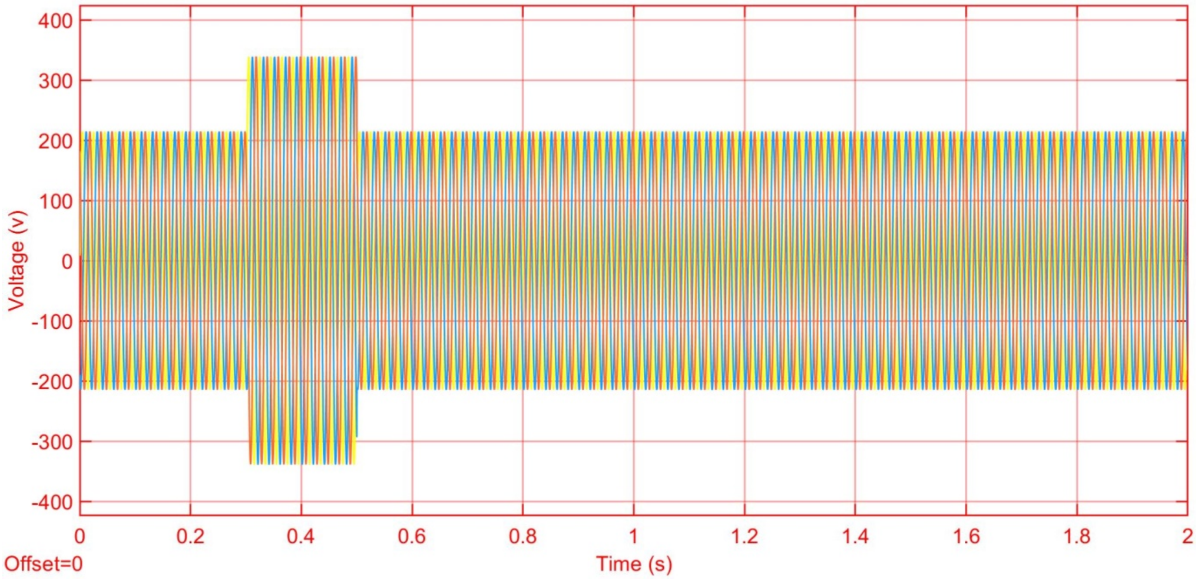

Fig 14 Grid Voltage (Without STATCOM and PSO algorithm)

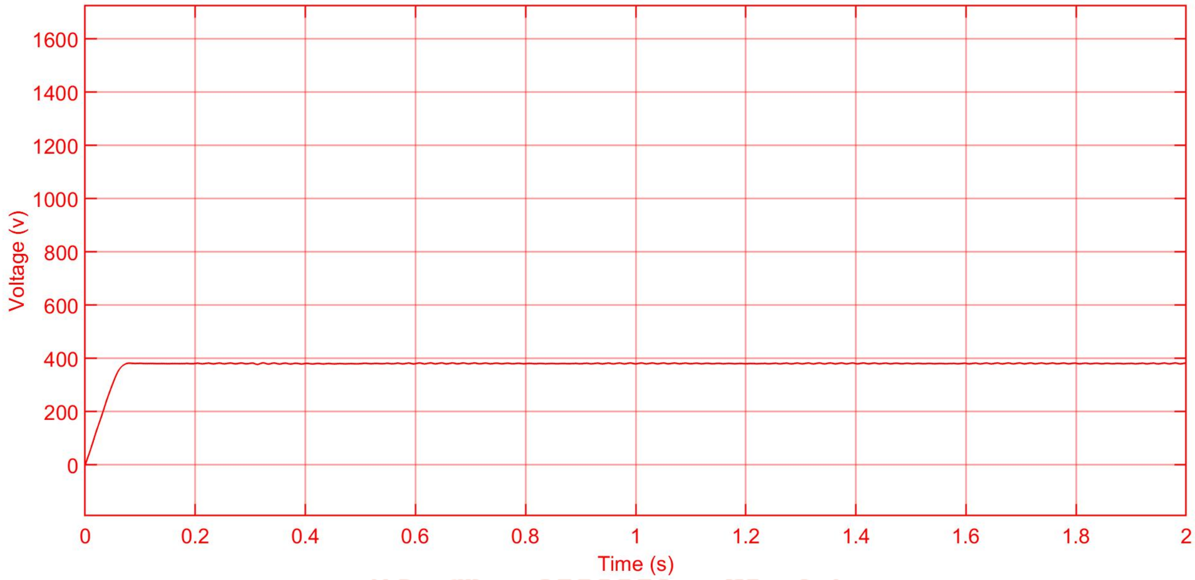

Fig -15 Solar array voltage (Without STATCOM and PSO algorithm)

Conclusion:

The system was simulated and tested in the MATLAB/Simulink environment, and the PSO optimization integrated in the M-file was called from Simulink to find the minimum network performance value. The PSO algorithm has shown an excellent way to find the best trades for Ig and Vg, but it seems impossible for humans to achieve optimal values. The simulation results for both voltage and current output curves are stable with reasonable THD for both controllers, but one still outperforms the other. Interrupting and monitoring drivers is very easy and fast. A disadvantage of the P&O algorithm is that the system's steady operating point oscillates around its MPP, wasting available energy. The choice of the perturbation step size is very important. The step size determines how quickly the MPP is reached. Faster tracking can be achieved with a larger step size, but the oscillation around the MPP increases. There is a trade-off between dynamic performance and stable performance.

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