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Research paper

A Particle Swarm Optimization based Fuzzy Logic Control for Photovoltaic System

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Abstract

A Particle swarm optimizer (PSO)-Fuzzy logic based MPPT is used for optimal control in renewable energy system. It uses buck-boost converter, which acts as a maximum power point tracking. The proposed inverter comprises of mainly three functions viz. MPPT, DC-side voltage regulation and output grid-connected current, over changing insolation level. The system is connected to the grid to supply ac power which is accomplished by globally locating the maximum power point of the array. PSO algorithm is used to optimize thefuzzy values accurately. The PV practical implementation is linked with theSimulink based PSO-FLC method.

Keywords:*MPPT, PV, P and O, PSO-FLC*

1. Introduction and Methodology

The emerging and promising technology for power generation is Photovoltaic (PV) renewable. Many different maximum power point tracking (MPPT) techniques have been used for enhancing thetransformation efficiency[1-5].Here we explain how PSO–FLC hybrid algorithm execute and update MF's and how they are capable to doing swarm optimization. The tuning of FL parameters is properly accomplished by PSO swarm intelligent technique. As discussed by Kennedy and Eberhart, the particle swarm nature is dependent on birds flocking and are employed to deliver optimized result. To provide exact results, the fitness function of corresponding particle is responsible. The relation to locate the final position and velocity of m^{th} and n^{th} particle among P total particle with single and global optima G_P and G_G, respectively can be mathematically given as:

$$V_m^{I+1} = V^I \omega + S_1 R_1 (N_P - X_m^I) + S_2 R_2 (N_G - X_m^I)$$
(1)

$$X_m^{I+1} = X^I + V^I \qquad (2)$$

Where,

ω = Weighing inertia
I= Iteration order
S_1,S_2= Accelerated constants
R_1,R_2€[0,1]
$N_{P,}$ N_G = Single and global optima

The error E and change in errordEof fuzzy logicinputs are dependent on MPPT controller. We can use equation approximately as dP/dV in MPPT obtained is nearly one.

Alternatively, the signal error can be calculated as output fuzzy controller transforms a linguistic variable to a numeric variable and a membership function as shown in figure 10 which is utilized for the stage of fuzzification. Due tofuzzification, a controller of analog output signal is produced which can convert to a digital signal and hence control the power of MPPT system. The FLC controller exhibits good efficiency of optimal operation. Also, the effect of fuzzy logic controller relies on the accuracy of error measurement, its diversity and the rules developed by user for basic table. The rules of the basic table can be continuously updated or can be adjusted by achieving optimal performance similar to the adaptive fuzzy logic controllerfor better efficiency and proper functions. This way, strong convergence to MPPT and minimal fluctuations of MPPT can be obtained. However, tracking of performance depends on the type of membership function.

As mentioned, the applied FLC variables based on MPPT is explained above. E and dEare two fuzzy values whose changes have been coined during K sampling. In order to make fuzzy decision by fuzzy rules to define dD variable i.e. the amount of duty cycle change of PWM,the input variables after fuzzification are provided to fuzzy inference machine. The complete understanding of the behavior of a photovoltaic system is requiredto design fuzzy controller and selection of fuzzy rules. The ultimate goal of maximum power point tracking of solar array is under various conditions of temperature, light intensity, charge and other factors.

We should propose fuzzy inference machine to produce ΔD variable, after determining the set of fuzzy rules and membership functions of the input variables is accomplished.

For this cause, Mamdani's inference method for making fuzzy decisions which are more renowned in control engineering sector and are used more than other inference methods and Max-Min Mamdani method in order to combine fuzzy rules have been exploited. Fig 1 shows standalone PV framework controlled through PSO-FLC optimizer. The power converter is triggered through optimized fuzzy variables. The tracked output is global maximum with different operating condition. Fig 2 depicts grid integration PV framework controlled through hybrid PSO-FLC controller. The Inverter is interlinked with power converter and utility grid [6-8]. The Swarm MPPT technique is used to optimize fuzzy values.

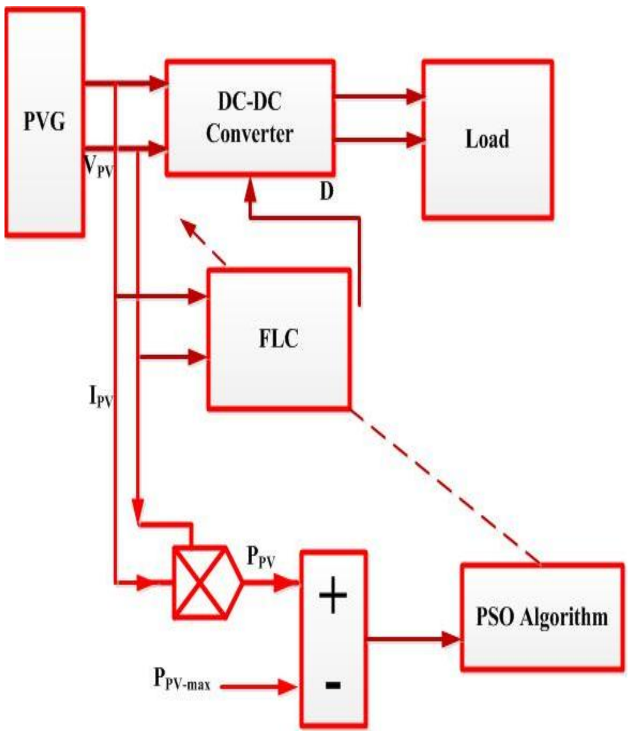


Fig. 1: Standalone PV controlled using PSO-FLC

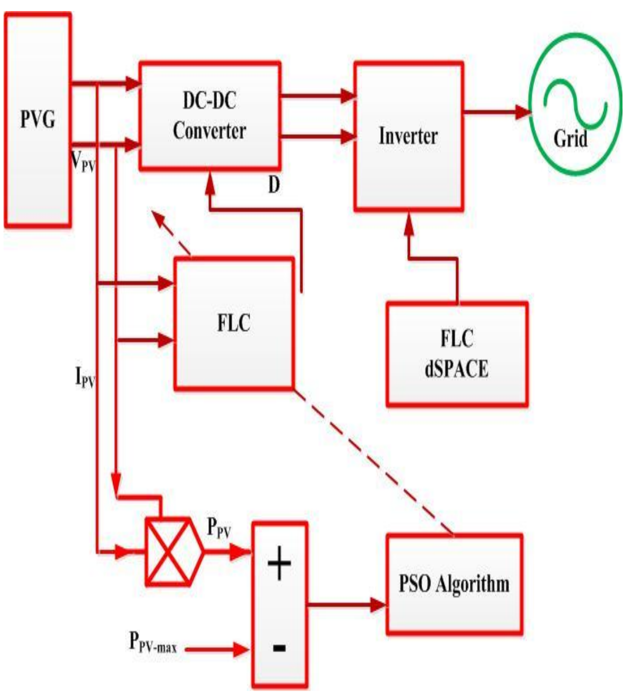
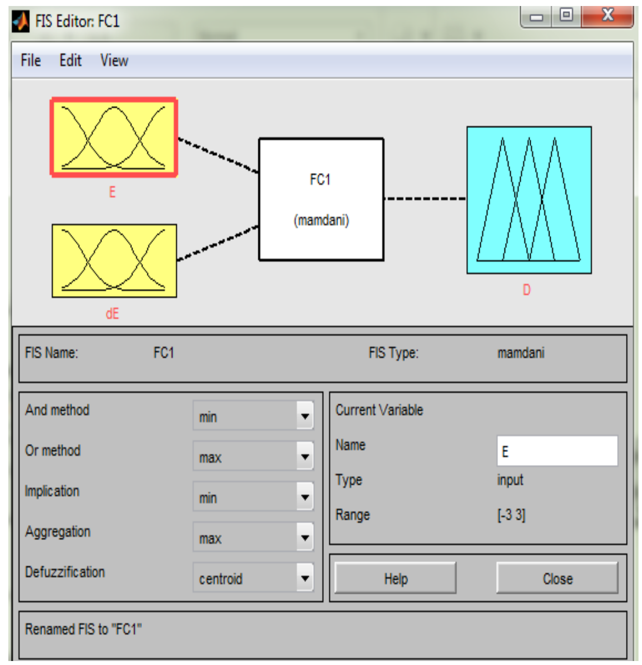
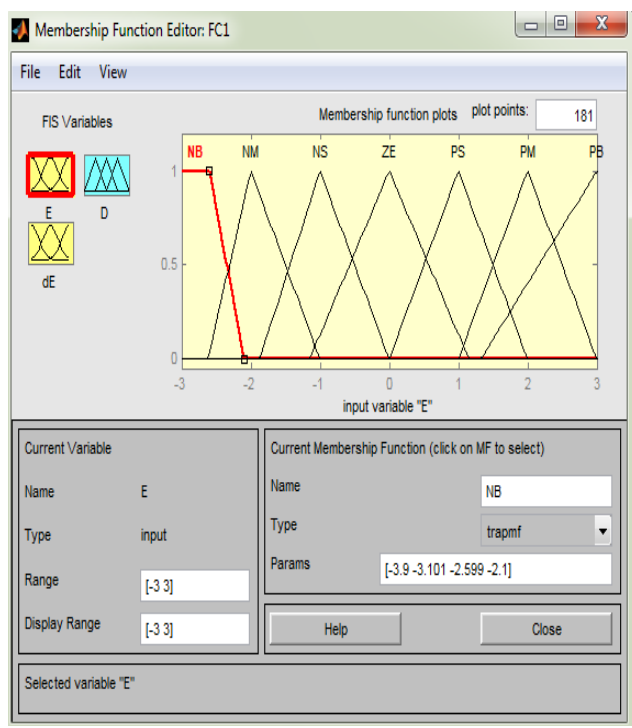


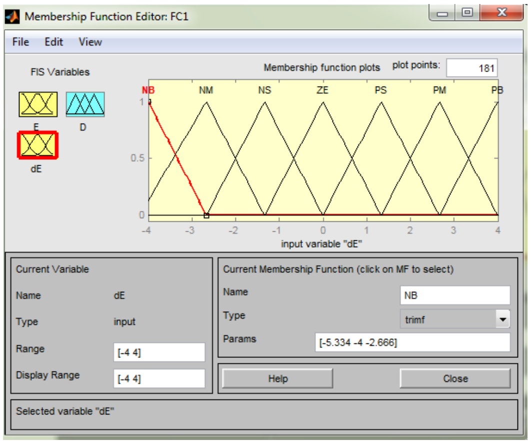
Fig. 2:. Grid connected PV controlled through PSO-FLC



(a)



(b)



(c)

Fig. 3:. (a) Inference editor (b) MF's E (c) MF' dE

Fuzzification is used to convert the fuzzy controller inputs from numeric variables to linguistic variables. Input and output variables are linguistic values, defined by including: NB (negative big), NM (negative medium), NS (negative small), ZE (zero), PS (positive small), PM (positive medium) and PB (positive big), which should be selected for each of the appropriate fuzzy membership functions. The starting choice of membership functions for linguistic variables is done with respect to the empirical knowledge of the photovoltaic system. To simulate the fuzzy controller, we make use of fuzzy logic software in toolbox of MATLAB[9,10]. At the beginning, we define a new environment to produce fuzzy controller in which we save FIS editor in the name of solar tracker. However, we should define any inputs of system say two inputs of input1 and input2 as E and dE. Now we have to define each inputs of E and dE according to existing membership functions in software that are compatible to figures for every two inputs, we use trimf and trapmf functions. Table 1 presents the PSO employed values during simulation.

Table 1:.PSO employed values during simulation

S.N	Parameter	Value
1.	PSO weight inertia	0.8
2.	PSO acceleration	1.7
3.	Minimum error of PSO	0.12

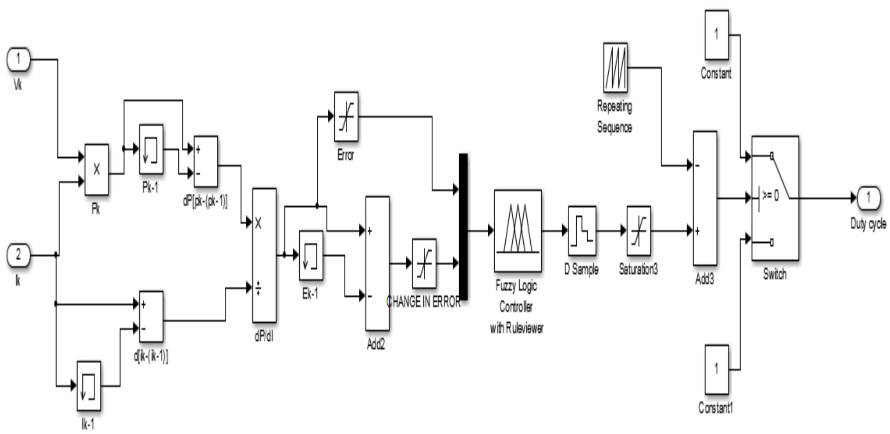


Fig. 4:. Fuzzy based MPPT controller designed using MATLAB

2. Simulation and modeling using MATLAB

Fig. 3and 4 depicts the MF's and MPPT implementation FLC inferencedesigned using simulink. With the careful adjustment of fuzzy values with optimized PSO is implemented and analyzed. Standalone/grid integration is also designed with Simulink and the performance is evaluated under various operating environment which are represented using Fig 5 and 6, respectively.

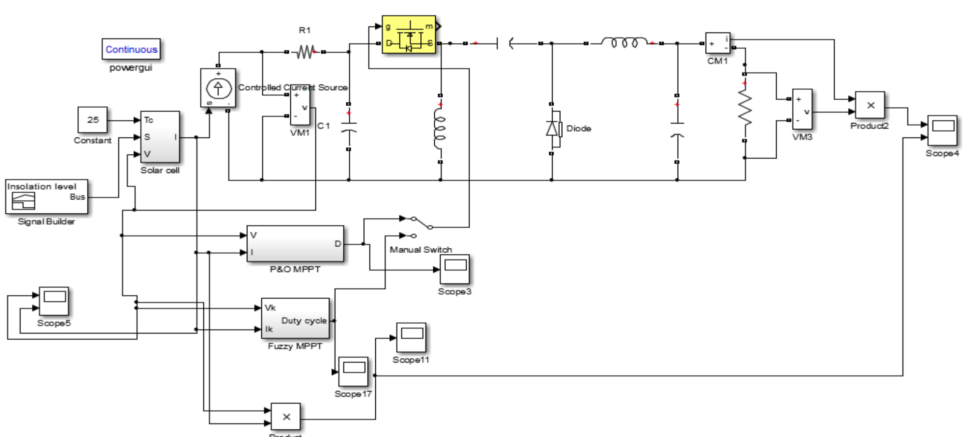


Fig. 5:. Proposed MPPT Vs. conventional P&O MPPT

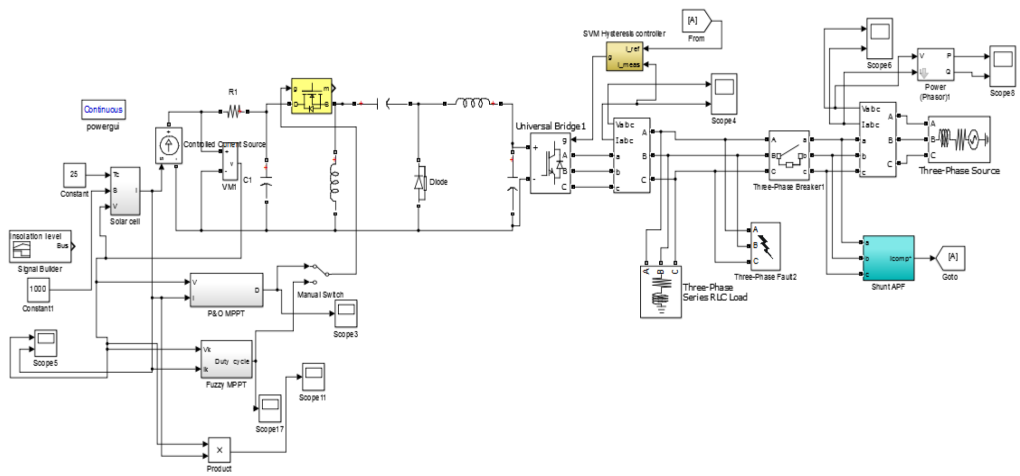
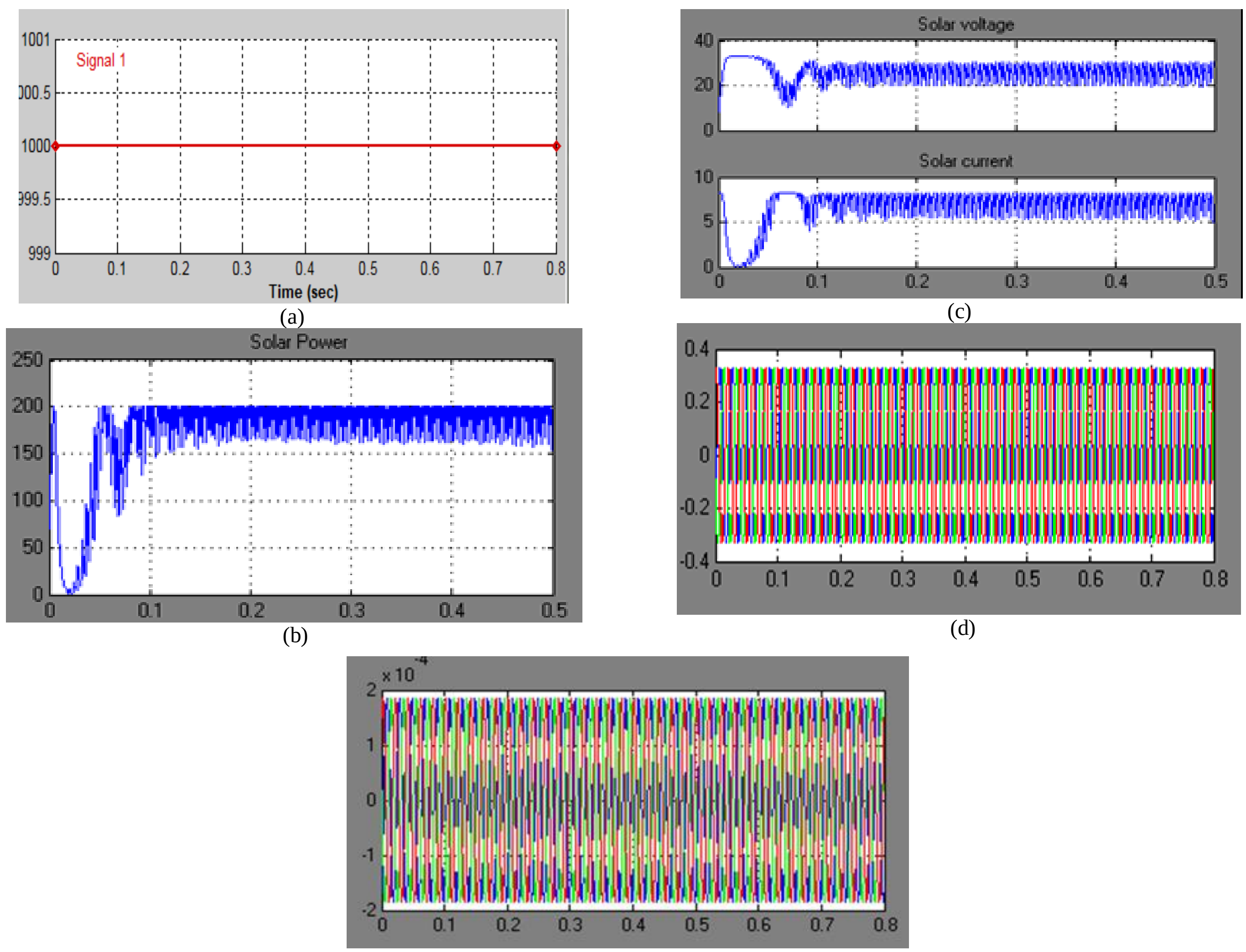


Fig. 6:. Proposed PV system using MATLAB/SIMULINK

2.1. Grid PV system using P and O methodology



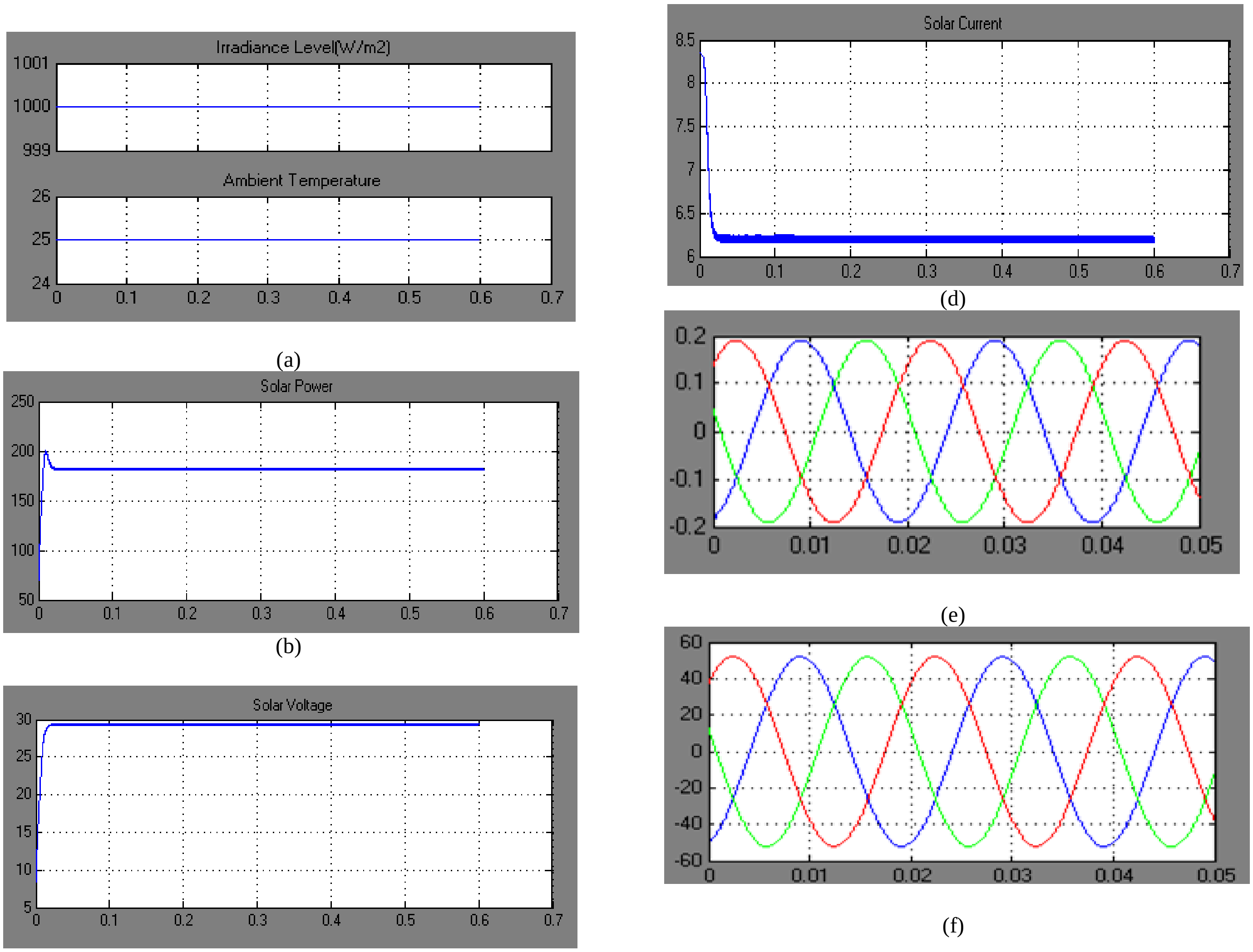
(a) (b) (c) (d) (e)

Fig. 7:. (a) solar insolation (b) Power$_{PV}$ (c) Voltage$_{PV}$, Current$_{PV}$ (d) Voltage$_{Grid}$(e)Current$_{Grid}$

In this section, the effective behavior is evaluated with PV framework controlled through P and O. Here, we make use of classical method for simulation implementation thus increasing the conversion efficiency of the photovoltaic system as compared to without using an MPPT algorithm. The conventional method P&O is not effective to track real MPPT, when the uniform temperature on the entire PV array is changing rapidly. Fig 7(b) shows that between 0-0.4 sec, P and O implementation is not able to achieveglobal output due to change in temperature 80-25^{0}C .

2.2. Proposed PV controlled responses

The FLC-PSO based MPPT has correct and accurate tracking efficiency with precise response compared to P & O MPPT shown in Fig 8.



(a) (b) (c) (d) (e) (f)

Fig. 8:. Constant input profile of insolation/ temperature (b) P_{PV} (c) V_{PV} (d) I_{PV} (e) V_{Grid} (f) I_{Grid}

3. Conclusions

A hybrid PSO-FLC controller is adopted for Optimal Control of MPPT in PV framework. The global optima with rapid convergence are accomplished with zero oscillation. The sine nature of utility grid is provided byFLC dSPACE interface. Different sets of environmental inputs are applied and tested with PSO-FLC method. In this paper Standalone/ grid integration is discussed and unity p.f behaviour has been analysed with optimized PSO-FLC controller. The proposed system is fully analysed by MATLAB/SIMULINK simulation.

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