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Stability and Power Quality issue during Solar Energy Integrated to Power Grid with Fuzzy MPPT Technique

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Abstract

Paper propose a technique to improve the stability and power control in two area power system by tuning fuzzy control with help of Maximum Power Point Tracking (MPPT). This paper summarizes the modelling of PV module and converter under different conditions. The power voltage of photovoltaic array is non-linear and it exhibits multiple peaks including many local peaks loads. To achieve track the global peak, MPPT is the important component of solar energy systems. Method is rigorous to generate new set of dada from fuzzy logic controller used in test energy system. Irradiance and temperature have been regarded as input to proposed controller to achieve better results and output will be most favourable voltage. Then the output voltage of PV module with fuzzy output voltage is subtracted to obtain the error. Also Genetic Algorithm (GA) is proposed for well tuning of control vector form fuzzy controller. Proposed control method, which is responsible for power quality such as low Total Harmonic Distortion (THD) and also improvement of voltage stability in test system.

Key words: Maximum Power Point Tracking (MPPT), Power Quality. Fuzzy based MPPT algorithm. DC-DC power conversion, photovoltaic (PV) power systems.

I. INTRODUCTION

Two area inter connected power system is considered with solar energy system has play crucial role to maintains stability and power quality aspects. Solar energy has offered promising results in the quest of finding the solution for the problem. The solar energy using PV modules comes with its own problems that arise from the

change in insulation conditions. Also it is a very important issue in power system operation and control for supplying sufficient and reliable electric power with good quality. These changes in insulation conditions severely affect the efficiency and output power of the PV modules. A huge research has been done to improve the efficiency of the PV modules and hence stability of system. Many methods of how to track the maximum power point [8] of a PV module of solar energy system have been proposed to solve the problem of efficiency and products using these methods have been manufactured and are now commercially available for consumers. As test system used for simulation of test power system is typically deals with power quality and stability issues by enhancing control strategy through techniques like fuzzy logic. This is most advantageous for more power utility firms with sufficient supply for power generation to meet the load demand by end customers.

II. SYSTEM REPRESENTATION

Different models have been used for depicting the PV module and two-diode model is found to be very accurate but it requires computation of parameters developing photovoltaic energy sources can reduce fossil fuel dependency. PV panels [5] are low-energy conversion efficient due to control maximum output power. Therefore, using the MPPT system is highly has been recommended. In the other word, the output power of a PV module varies as a function of the voltage and also the MPP point is change by variation of temperature and sun irradiance [4]. A solar cell can be represented by a current source connected in parallel with a pn junction diode; The current source is the photocurrent generated by incoming sunlight and the diode equation is changed to

$$I=I_0(e^{qV/kT}-1)-I_{SC} \quad \text{-----(1)}$$

In fundamental equation of solar cell I_0 is saturation current, q is electronic charge, k is Boltzmann's constant, T is absolute temperature of the cell, V is voltage impose across the cell. While the voltage is always positive, the current is always negative. This is understandable because the diode is a passive device which consumes energy.

The output power of a solar cell is determined by the product of voltage and current, P = IV

As discussed, it is always smaller than the product of the short-circuit current Isc and the open-circuit voltage Voc, the rated power of a solar cell is the maximum power output with an influx of photons of one sun, or 1 kW/m, under favorable impedance-matching conditions. In general, the condition of maximum power is

$$dP = IdV + V\,dI = 0 \quad \text{-----(2)}$$

and in otherwords

$$dI/dV = -I/V \quad \text{-----(3)}$$

According to the solar cell equation 9. 2, the output power as a function of the output voltage V is

$$P = IV = I_{sc} - I_0(e^{qV/kT}-1)V \quad \text{-----(4)}$$

It observe that the voltage of maximum power is only slightly smaller than the open-circuit voltage. Introduce a voltage offset v, we write

$$V = Voc-v \quad \text{-----(6)}$$

PV modules have unique current v/s voltage (I_{PVM}-V_{PVM}) characteristics. From the P-V and I-V characteristics, it is clear that the PV systems must be operated at a maximum power point (MPP) of specific current and voltage values so as to increase the PV efficiency. The voltage that corresponds to the module maximum power varies with temperature and insolation variations, so a MPP tracking system is needed to ensure that we stay as close as possible to the maximum power point

A) Fuzzy Controller:

Fuzzy logic controller inputs error 'e' and a change of error 'Δe'. These the two inputs for fuzzy logic controller are taken from the comparator of actual and reference values that indicate input variables change of error and derivative of change in error[9]. Linguistic terms used for the membership functions are such that are terms NL(Negative Large), NM(Negative Medium), NS(Negative Small), ZE(Zero), PS(Positive Small), PM(Positive Medium) and PL(Positive Large). Some examples of decision table are given below

1. If (Δe is NS) and ($\dot{\Delta}$e is PS) then (Control Vector, u is NM)
2. If (Δe is PL) and ($\dot{\Delta}$e is PM) then (Control Vector, u is ZE)
3. If (Δe is NL) and ($\dot{\Delta}$e is PL) then (Control Vector, u is NL)
4. If (Δe is PM) and ($\dot{\Delta}$e is NL) then (Control Vector, u is PS)
5. If (Δe is ZE) and ($\dot{\Delta}$e is NM) then (Control Vector, u is NS)

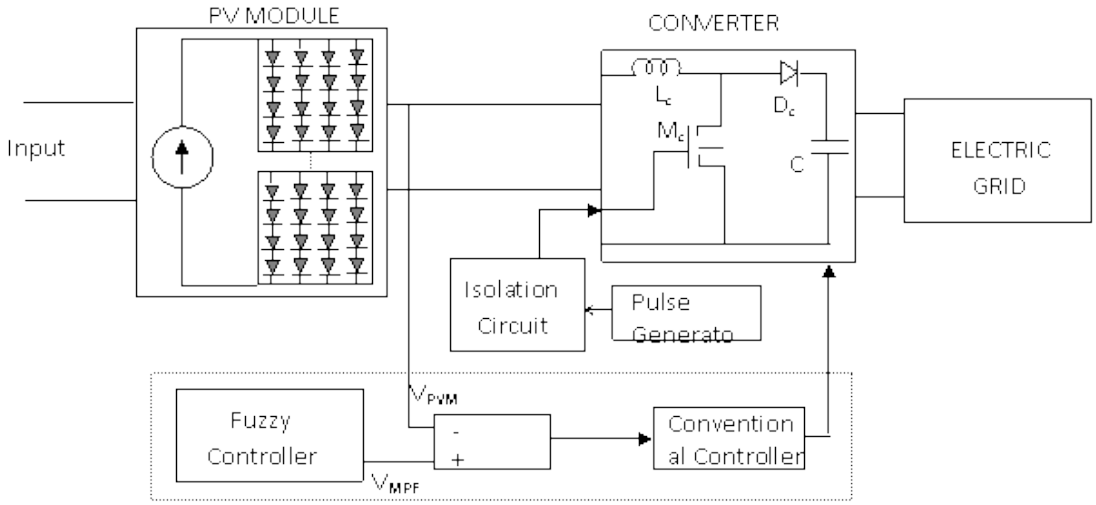


Figure 1. Solar PV system with fuzzy controller.

Propositions (IF, THEN) with all 49 rules are used to develop programming code in MATLAB. After developing rule base in matlab, the test system was checked for different condions. The optimum step size should be calculated to give a low steady-state error at an acceptable speed of system response. For the system under consideration, the sizes of the PV array can obtained by genetic algorithm

B) Genetic Algorithm:

Test system can be done with all defined control vector of block diagram shown in figure with original values of data. In many available solutions, with help of many fitness functions GA plays crucial role for new set of data accuracy. The evaluation process [15] with development algorithm tic steps goes in natural way of related GA theory and concepts. With different stages like Parent Selection and Reproduction, Crossover, Mutation can achieve the better set of generation from test data for solution has to complete.

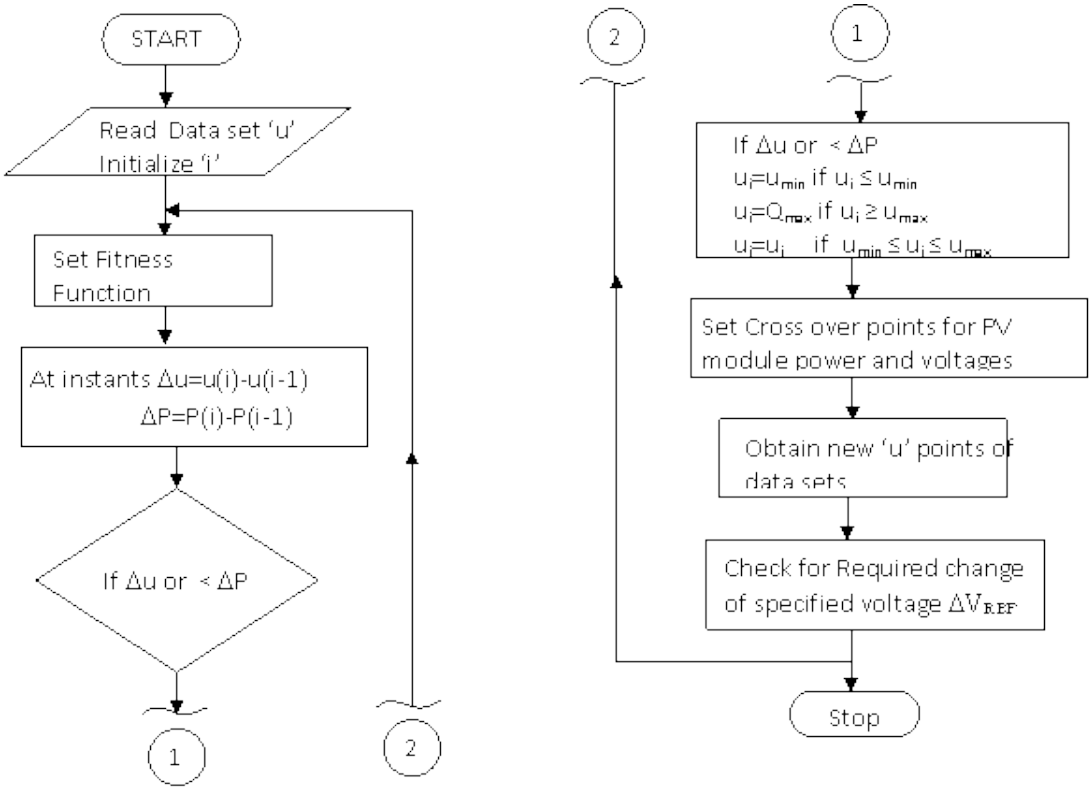


Figure 2. Gentic Algorithm for new generation set of data

For getting new generation quietly good and fit for all possible test conditions of system environment, the process of all stages said above has to be complete with most care and systematically. The sequential steps for searching optimal solution for change frequency using GA as shown in figure 2.

III. PROPOSED CONTROLLER FOR TEST SYSTEM

Test system with PV module and converter is considered to test power quality when power system is connected to grid. Subsystem-1 and Subsystem-2 are converters of IGBT element for conversion with common DC link. Irradiation and temperature are Inputs to fuzzy controller.

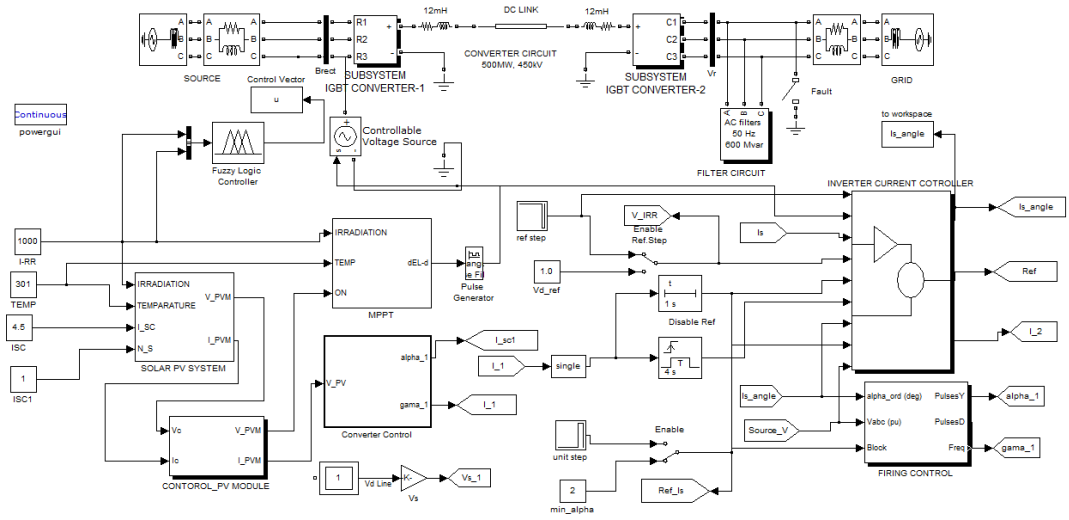
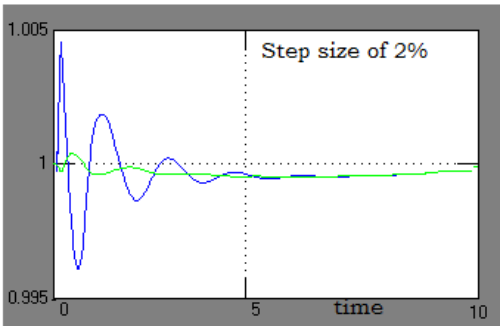


Figure 3. Simulation model of solar energy system connected to grid

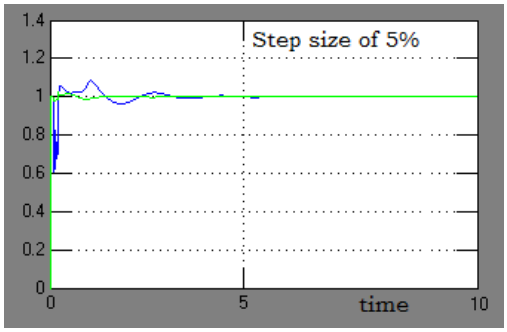
Control vector imported to workspace of matlab and algorithm was developed to obtain new set of data points. In proposed method, control vector from is well tuned by genetic algorithm GA. Right side part of test is control diagram and controllable signal directed to controllable voltage source. Firing circuit also depicted for control circuit at two sides of conversion process. Test is checked with filter circuit at convert output side and also THD percentage which is a one of parameter of power quality issue.

IV. SIMULATION AND TEST RESULTS

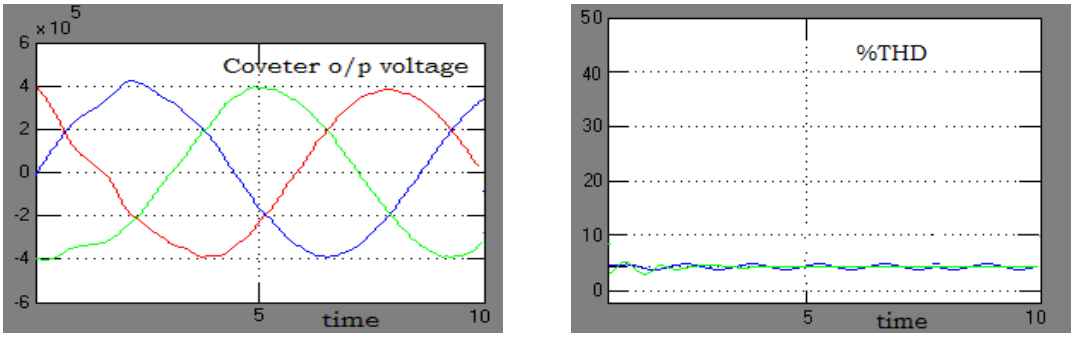
With proposed fuzzy based controller with GA algorithm, simulation has been carried for test system shown in figure4. Simulation has been done by using matlab simulink and programming. Results with controllers called fuzzy and GA algorithm are together gave better the performance as compared conventional controller.



(a)



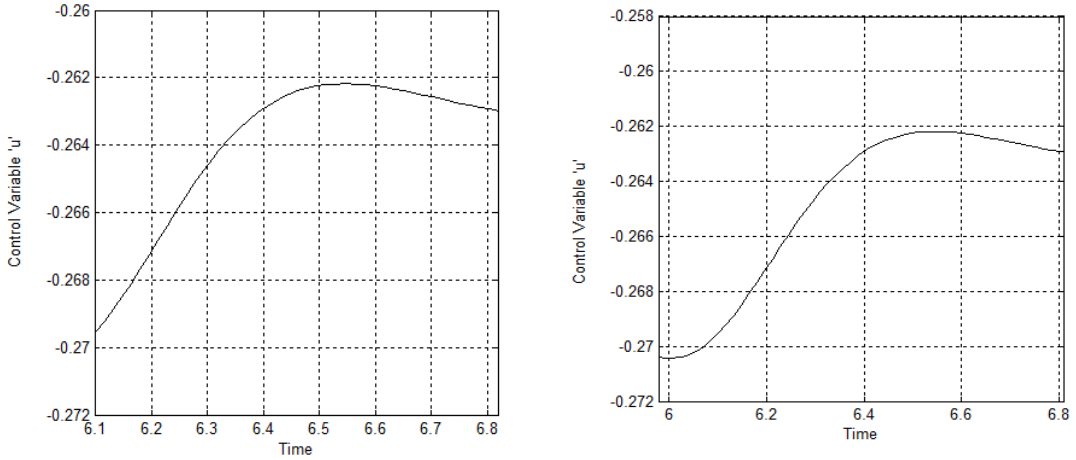
(b)



(c) (d)

Figure 4. Simulation results of test system: (a) PV array voltage with 2% step size; (b) PV array voltage with 5% step size; (c) Converter output voltage; (d) % of THD

Performance of system has been improved as which PV array voltage with 2%, 5% step size increase and also with reasonable minimum THD, as shown in figure 4a to 4d. Control vector with increase in voltage of PV module is shown in figure 5a and 5b.



(a) (b)

Figure 5. Control vector, 'u'; (a) with 2% increase in V_{PVM} ; (b) with 3% increase in V_{PVM}

V. CONCLUSION

MPPT control along with fuzzy based GA algorithm strategy is proposed for increase of quality and performance solar energy system when connected to grid. Genetic Algorithm (GA) is proposed for well tuning of control vector form fuzzy controller and observed that improve in voltage stability and minimum THD. Even PV module voltage is increase in 2% and 3%, proposed technique improves the response. In

Proposed control method gives reasonable good results for power quality such as low Total Harmonic Distortion (THD) and also improvement of performance in test system.

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