Using a fuzzy controller, detect partial shading and increase maximum power from a shaded PV array

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Abstract: In this manuscript detection of partial shaded condition and enhance maximum power from shaded PV array with adopting an intelligent fuzzy logic controller (FLC) is presented. The Photovoltaic (PV) systems are suffering with the diminishing output power due to the partial shading conditions. The conventional Maximum Power Point Tracking (MPPT) methods are failed to regulate maximum power point. Hence, a novel approach is discussed to identify the partial shading conditions. The proposed method has developed based on the voltage at first peak in P-V characteristics curve to decide the partial shading status. The performance depends on shading patterns and position of the solar panels in solar PV array. Hence, a new interconnection method has proposed, which disburse the shade to maximize the power output of partially shaded solar Array. The proposed system is tested under different partial shaded conditions for change in irradiation. As the solar panels receive continuous change in irradiation, the P-V characteristics of solar array experience multiple peaks or local peaks. The multiple peaks with conventional Total Cross Tied (TCT) connection are avoided with a new interconnection method.

Keywords – PV array, fuzzy MPPT, Partial shading

Introduction:

For rapid growing of population providing electricity to the society is biggest challenge in front of electrical engineering. Electricity is act as a backbone to run any industry, so implementation of generations growing very fast in every ware. In recent years the absorption of renewable energy sources (RES) are multiplied in that solar (PV) and wind is more dominant because of it's numerous significances. Extraction maximum power from wind and solar is possible by adaption of intelligent control strategies. It enhances the transient-steady state performance of the hybrid generation. Wind strength has emerge as certainly one of the most important and promising assets of renewable strength. This needs extra transmission capability and better approach of preserving system reliability. Power generations are broadly available in two ways, Conventional energy sources (CES) and non conventional energy sources (NCES). CES sources are hydro and thermal. In thermal power generation raw material used is fossil fuel (coal) may be completes next two decades. For hydro Power plants main source water and it is available in seasonally so power generation not done throughout the year. This two power generations inject various fuel gases into the environment and pollute the atmosphere. These problems are much extent overcome by using NCES energy sources. NCES sources (Renewable energy sources-RES) are greener and eco friendly nature, like solar, wind and geo thermal. Power generated throughout the year. It doesn't develop any fuel gases to generate the power. CES are hydro and thermal.

The improved performance of hybrid power generation has been presented in literature. That is basically batteries (lead-acid batteries [1]) are the small scale RES systems, stores electrical energy works as temporary energy source where PV panels & wind energy is n't compliance. Like this way uninterrupted power is supplied to the load. Energy pricing is confirmed to the customers (loads) as per usage of RES and battery, grid. Optimum pricing is involved when RES sources are used efficiently. Solar power is classified as Stand-alone PV f and the grid-connected PV systems [2-4] The major differences between these two solar energy conversation systems (SECS) are that in stand-alone frameworks the PV output is equally balanced with the load demand, Grid connected SECS both PV and grid are responsible for to achieve the load demand. When non linear loads such as three phase bridge rectifier is connected in the circuit grid integrate PV frameworks are suffered with power quality concerns as harmonics, voltage sags, voltage swells etc. This power quality problems are occurred due presence of non linear loads in the distribution (load).

Power quality enhancing in grid integrating PV-wind is described [5-7], the nonlinearities, harmonics are occurred mainly due to presence of non linear loads in the network. Maximum

Power extracts from solar and wind with employing petrub-obseravation, incremental conductance and fuzzy controllers. The fuzzy MPPT algorithm is employed and simulation results are discussed by B.Subuddi [8], proven fuzzy MPPT works well compared to various PI control to controlling the switching of VSC.

The buck converter, boost converter, and buck boost converters are the predominant and frequently used Dc-Dc converter. The simple expectations of these circuits rely on the input dc voltage being chopped with a particular service cycle to achieve desired output voltage levels. Usually, the switching frequency is kept at constant length, and the pulse width must be modified. These circuits are easy to produce but suffer from drawbacks that

impede their use in applications with higher power and higher voltage. A complete assessment and review of dc-dc boost converter techniques for the photovoltaic system was expanded in this article. The assessment of the dc-dc buck converter, dc-dc boost converter, and dc-dc buck-boost converter was also slightly elaborated. It is inferred from the analysis that dc-dc boost converters possess major advantages over other converters due to their improved dynamic efficiency and the cheapest deployment procedures.

System Configuration: The schematic diagram of PV array is shown in figure.1.

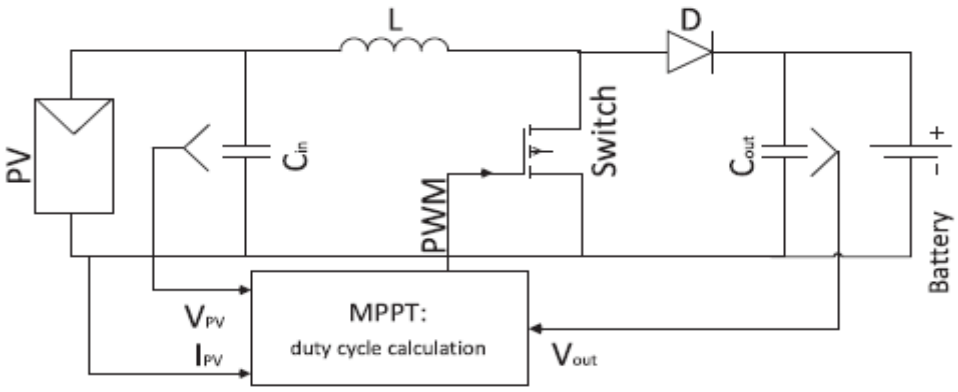


Fig.1. fuzzy based PV array with battery

A. Design of PV array:

The solar cell practically represents current source with shunt by diode. Its configuration is shown in figure.2. where shunt-series resistors are protect the PV cell.

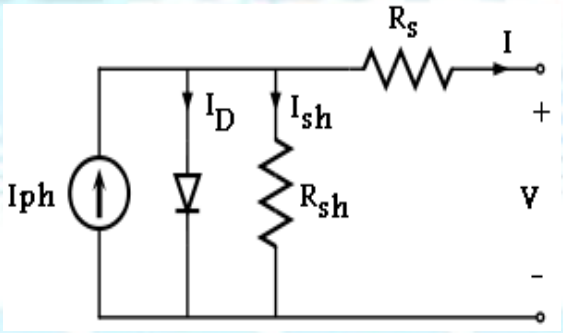


Fig.2. structure of PV Cell

The load current (I), mathematically expressed as

$$\mathrm{I} = I_{ph} - I_s\left(\exp q\frac{(v+R_sI)}{NKT}\right) - 1 - \left(\frac{v+R_sI}{R_{sh}}\right)$$

Where
Iph = solar current
Rse and *Rsh* are the series and shunt resistors
q = electron charge
V = voltage available at diode
K = Boltzmann's constant

T = temperature

To obtain the desired voltage from PV cell 'n' no. of PV cells are connected in cascade manner

$$V_{series} = \sum_{j=1}^{n} V_j = V_1 + V_2 + \ldots\ldots\ldots + V_n \quad f$$

$V_{seriesoc} = \sum_{j=1}^{n} V_j = V_{oc1} + V_{oc2} + \ldots\ldots\ldots + V_{ocn}$ for I = 0

$I_{parallel} = \sum_{j=1}^{n} I_j = I_1 + I_2 + \ldots\ldots\ldots + I_n$

$V_{parallel} = V_1 = V_2 = \ldots\ldots\ldots = V_n$

B. Fuzzy MPPT algorithm:

The researchers designed and introduced different topologies for dc-dc boost converters to strengthen essential problems such as device efficiencies, gains in voltage and in the capacity to carry power. There are few methods that describe stepping up the voltage without the need for longer service cycles and may use multiple cell interleaving to rise the output power. Major classifications of dc-dc boost converters have been analyzed using their operational principles to identify the study gap in the dc-dc boost converters area. It is concluded from the analysis that dc-dc boost converters will have excellent advantages over other converters.. Now a day's controlled switching pattern is done by fuzzy MPPT algorithm to extract the peak power from the PV module. This fuzzy based DC converter provides less oscillatory voltage to the series VSCs which improves dynamic performance and overall efficiency of the PS network. The structure of fuzzy based DC-DC converter is shown in Fig. 3.

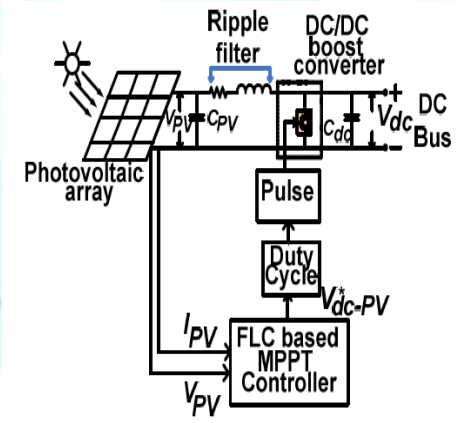


Fig. 3 Structure of fuzzy based boost converter

Proposed Control Scheme:

The overall system performance of grid connected hybrid connected hybrid power generation is controlled switching pattern of VSC. This VSC is operated with pulse production. This pulse generation is activated by intelligent fuzzy PI settings. Where fuzzy is operated w.r.t to variation of error signal. The rules are has been mentioned in below the proposed fuzzy control scheme is shown in fig.4.

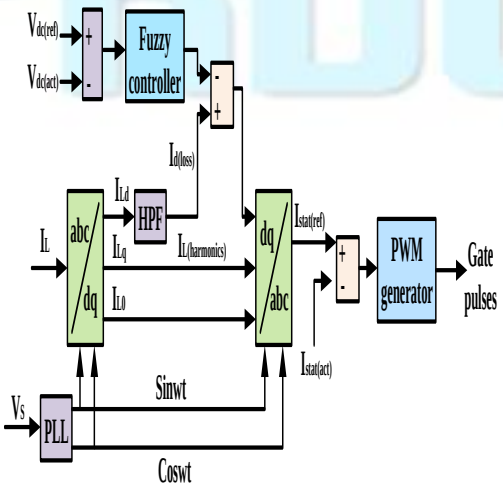


Fig.4. Proposed Fuzzy Control Scheme

Fuzzy logic rationale contrasts with both in idea and substance from conventional multivalve legitimate frameworks systems. Such as NB, NM, NS, ZE, PS, PM and PB those are stands for negative big, negative medium, negative small, zero positive small, positive medium, positive big respectively. The Fuzzy legitimates are shown in triangles in figure.5

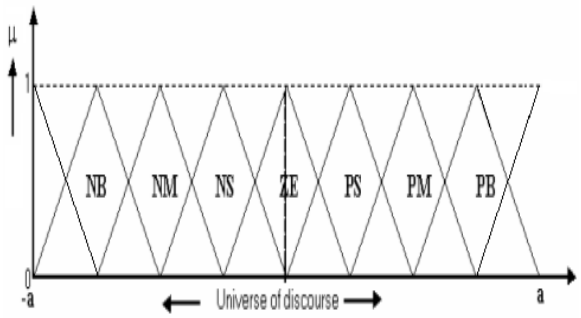


Fig.5. Fuzzy legitimate frame work for 50% overlap varying –a to +a

Simulation Results:

The MATLAB model of fuzzy based PV array with grid connected is shown in figure.6.

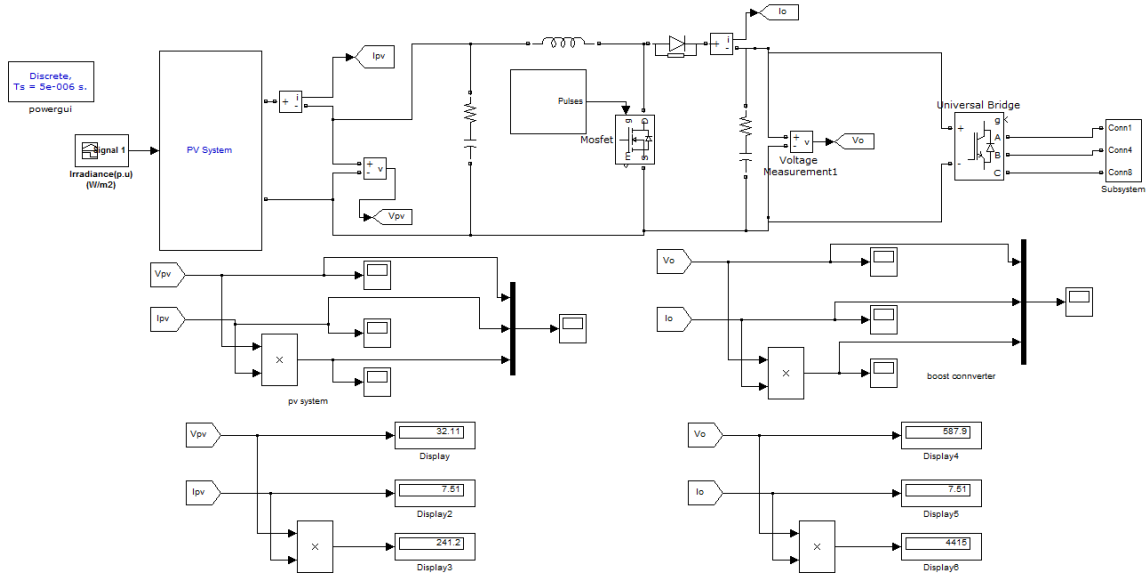


Fig.6 fuzzy based PV array

I-V characteristics and P-V characteristics of PV array is shown in figure.7a. And figure.7b

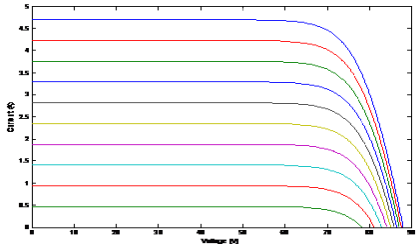


Fig.7a. I-V characteristics of solar array

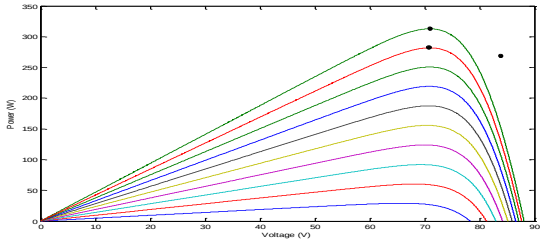


Fig.7b. P-V characteristics of solar array

When all the modules receive uniform irradiance, the string Power-Voltage (P-V) characteristic has a unique peak under partial shading conditions; the P-V curve of the string develops multiple maxima. Most of the GMPPT methods proposed in literature are incapable of distinguishing between uniform and partial shading, and thus employ global search even under uniform insolation conditions. The transition from uniform irradiance to partial shading I-V and P-V characteristics are shown in below figure.8a and figure 8b

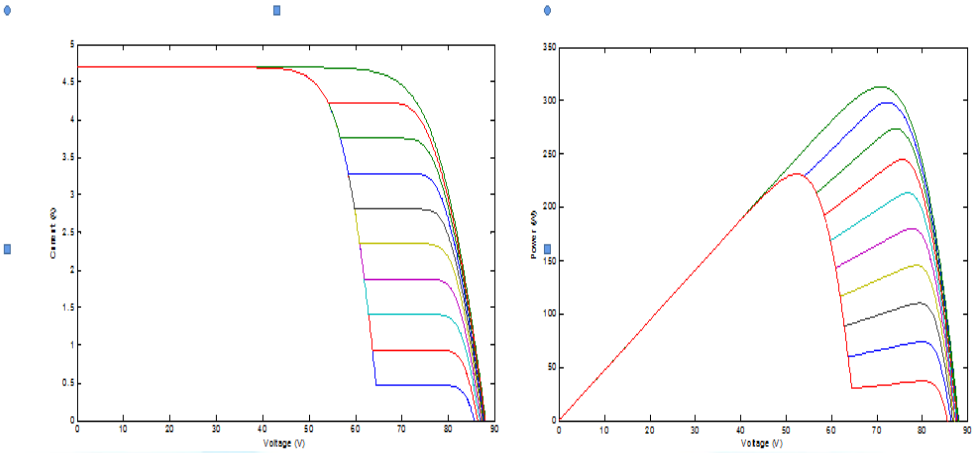
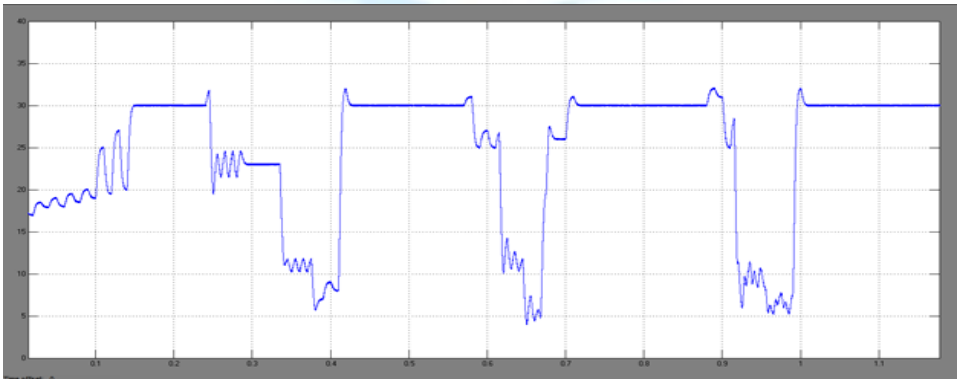
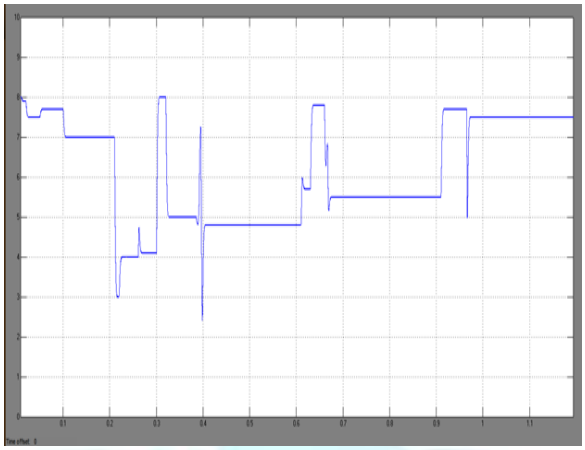


Fig.8. I-V and P-V characteristics of PV array under non uniform irradiance

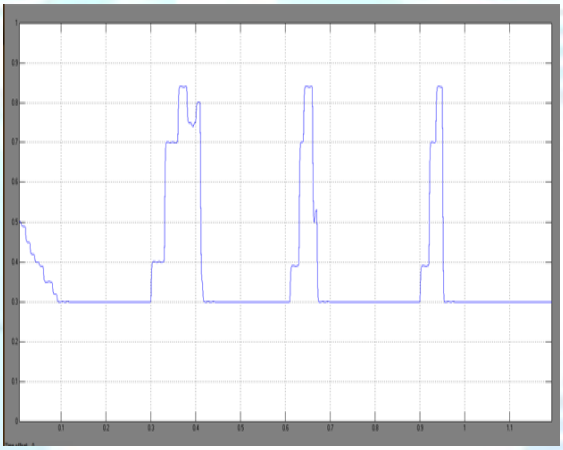
The output voltage, current, power of PV array and duty cycle is shown in figure.9a. to figure.9d



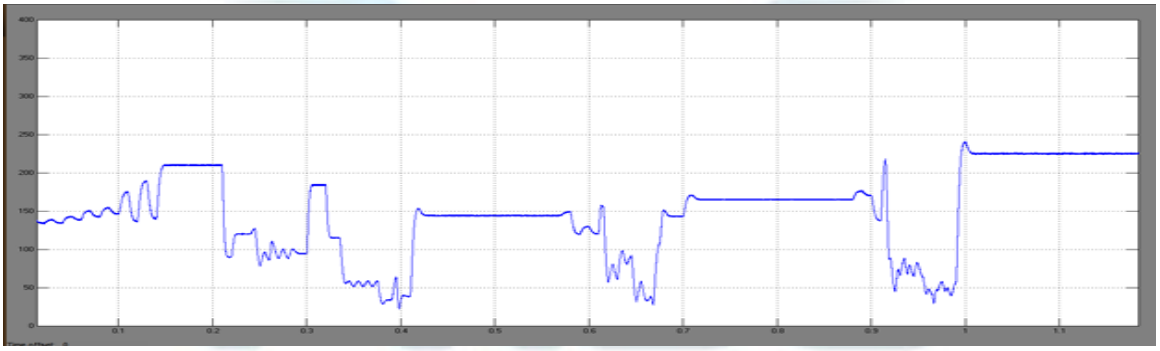
(a)



(b)



(d)



(c)

Fig. 9 PV array's (a) voltage, (b) current, (c) power, and (d) duty cycle waveform

Conclusion:

This manuscript presents a novel interconnection method is enhance the output magnitude of PV array i.e. solar output voltage and currents. Improved the efficiency of the shaded PV array with proposed technique, the detailed explanation for changing panel locations without changing electrical connections is illustrated with tables and figures. Simulation results clearly confirm and demonstrate that the magic square connection gives better power output than TCT configuration. The fuzzy based MPPT method successfully eliminated the local peaks presented in TCT configuration, which makes ease for the maximum power point tracking.

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