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PV Array Based Closed Loop Control of Quadratic Boost Converter

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Abstract:

A quadratic boost converter topology based on a high conversion ratio dc/dc converter with an active zero-voltage switching (ZVS) snubber circuit is developed for PV system application. Combined with a reboost inductor, a coupled inductor and charge-pump circuits are proposed to achieve high voltage gain with quadratic function. A front inductor is proposed to reboost the voltage gain to make the output voltage higher. The converter operating principle of the proposed conversion scheme is described in the detailed converter analysis. Simulation and experimental results are used to verify and validate the performance of the quadratic boost converter with the PI and fuzzy controller for PV inverter system.

I. Introduction:

Renewable energy sources play important role in electricity generation. Several non conventional energy sources such as solar, wind, geothermal and also biomass can be generation electricity is so helpful to our daily life. Photovoltaic generation is really becoming increasingly a renewable source, since it give numerous benefits like to incurring absolutely it will operate without fuel, no pollution, required little maintenance, and also totally no noise, among others. The photovoltaic voltage current (V-I) characteristic are depends upon the irradiation and temperature. For generating maximum output power and also opretes with peak efficiency by taking the Maximum Power Point (MPP) to build the V-I and the V-P curves. The maximum Power Point tracking is a technique which is used to track the maximum PV system output power.In a PV system solar array Regulation of MPPT is important. Based on their efficiency, speed, hardware implementation, cost, popularity we will put operation to implement MPPT technique which is the best technique used in PV systems [1, 2].

One of many widely taken strategies in MPPT is actually P&O due because of its uncomplicated as well as simply implementation. In this paper, operation of the boost converter and to eliminate the distortions in the output voltage by using PI controller with combination of Fuzzy controller. And also to minimise the dynamic stability and pick up efficiency. Simulation and analysis of PI controller with fuzzy logic control are presented.

II. Modelling and characteristic of solar panel:

The solar cell model is based on the pn semiconductor type where the DC current is generated in that solar cell when the light is exposed on it. The representation of the solar cell based from the equivalent circuit which consists of parallel and series resistance, diode, ideal current source. The generating power of the solar cell is mainly depend on the temperature and solar irradiation. The solar irradiation that is directly proportional to the generated current by the current source. In the external contacts the voltage loss are represented by the series resistance and the shunt resistance represents the leakage current. The output current and output voltage can be expressed by an equation through the mathematical model of the PV system [5, 6].

$$I = I_{ph} - I_0 \left[exp\left(\frac{q}{kTA}(v + IR_s) - 1\right) - \frac{(v+IR)}{R_{sh}} \right] \quad \text{--------- (1)}$$

Isolation level and working temperature of the solar cell is generated Photo current (Iph) is expressed by an equation.

$$I_{ph} = \left(I_{sc} + K_1(T - T_{ref})\right)\lambda \quad \text{--------- (2)}$$

where Rs and Rsh are usually your own sequence in addition to parallel equivalent resistance, np in addition to ns usually are your current quantities regarding PV panels throughout sequence

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along parallel, q may be the electronic charge, Isc would be the light induced current, Io could be the reverse saturation current, η is the diode ideality factor and k is the Boltzmann constant, respectively. This really is obvious which the PV array output power will certainly vary via temperature T in addition to irradiance S. The characteristic of the PV array is explaned by the curve which represents the current with respect to voltage (I V) curve and the (P V) curve that represent the power with repect to the voltage and also describe the Maximum Power Point (MPP) of the PV array tend to be viewable within only two under considering that the PV array output power always varies applying various other temperatures along with irradiance, a good MPPT controller That tracks your MPP easily in addition to accurately can be necessary. There are lots of algorithms capable of track solar array MPP under a variety of parameters and environmental conditions. Your perturb-and-observe program is the widely taken steps since the The item is straightforward to help implement [12].

for the P&O algorithm, ones PV output power is actually maximized coming from adjusting an step duty cycle change in which the PV output power is actually consumed by measuring your current PV voltage and current. regardless of whether a supplied perturbation leads to help a great increase (decrease) at the output power, your own after that perturbation will keep your same (opposite) direction. the advantage of your P&O controller is actually its' low cost ALONG WITH simple and easy implementation but It has a number of disadvantages like continued perturbation though the technique is usually at MPP to be able to merchandise a series of energy oscillation and increase your own power losses. These kinds of disadvantages can be improved by employing ones fuzzy logic algorithm into ones MPPT controller [8] At the converter output side we connect a dc/ac inverter to transform the energy into the AC output load. The PV panels need to be grouped and configured in series and parallel to provide enough voltage and power according to the desired load. The converter will provide a high output voltage DC link and the inverter transforms it into AC output by maintaining the energy balance on the dc bus. At the output load we use an inverter with the dc-bus control and filter to transform the harvesting solar power dc voltage into AC output and maintain the output voltage as a 60Hz, 110Vrms sinusoidal wave.

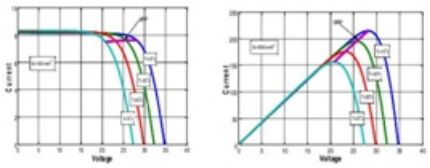

Fig.1. (a) V I,P V Characteristics of PV module at constant temperature and varying insolation's, (b) V I, PV Characteristics of PV module at constant insolation's and varying temperature.

III. Solar panel Characteristic:

The short circuit current (Isc) and open circuit voltage (Voc) are the two constraints, which are helpful to draw the I-V curve.

(1)The maximum current which is generated by the PV array where the solar cell is short circuited that current is known as short circuit current (Isc).
(2)The maximum voltage which is collected at the end terminal of the solar cell is known as open circuit voltage (Voc).

The PV output current and PV output voltage that are affected by the changes in irradiation and temperature ie., hotness respectively. Where the PV and load are connected through straight combination which are resolute to the functioning point by connection between the I-V curves of load and the PV array. For example with regard to any kind of resistive fill up R, It has immediately line I-V characteristic with slope 1/R, That gives individual operating point regarding a certain insolation level, via varying Force code R, it's we V curve slope varies also consequently your current functioning point varies relying upon these kinds of variation. likewise for a good specified program code of an resistive fill up R, This provides your own MPP of any PV as a possible functioning point, but That may be happened lone regarding single insolation level.

IV. TOPOLOGIES DESCRIPTION:

A boost converter is one of the important converter where used to step up the dc-dc power. In this converter MOSFET act as a switch where it operates the action by the PWM input signals. In this boost converter there is a two different path of operation.

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Where in path 1 the switch is in ON position the voltage will flow direct to the load and in this operation Diode is in OFF position. Where in the path 2 the switch is in OFF position the charge which is stored in inductor will flow to the load. And also the operation of the switch is depend upon the duty cycle of the transistor expressed in a equation

$$\frac{V_o}{V_i} = \frac{1}{(1-D)} \qquad \text{---------- (3)}$$

Where Vi is the PV output voltage, Vo voltage of boost converter, D is duty cycle, that can be expressed by equation.

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$$D = \frac{T_{on}}{T} \qquad \text{---------- (4)}$$

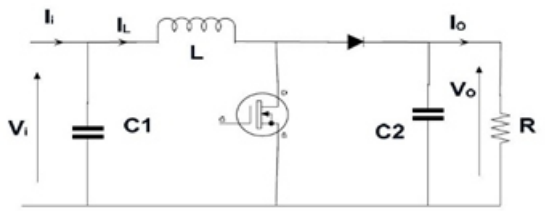

Fig.2. Boost converter Circuit diagram

Where Ton is time when MOSFET is switched on, T is cycle period time. PWM is the Pulse generating device which is given control signal to operate the transistor. The transistor operation is depending upon the PWM where it will give signal to the transistor when it will turned on and turned off. PWM operates at constant frequency i.e T is constant and Ton is varying, so D can be varied from 0 to 1.

V. MPPT CONTROLLER:

For extracting the maximum available power from the PV panel at any instant level where that to investigate that maximum operating point, which that MPPT is basically need for a real time development.

VI. MPPT using Fuzzy Logic Control:

There is number of controllers for PV systems among this Fuzzy logic are one of the very important and prevailing control methods.

Multi rules based resolution and multivariable consideration are known by this controller. Since over last decade this Fuzzy MPPT is popular one. The main advantages of the Fuzzy logic controller (FLC) are no need accurate input and also no need to have exact mathematical model and nonlinearity will also handle by this FLC. Error (E) and Change of error (CE) are the two input variables of FLC, mainly it consists two inputs and one output. The error and change of error is expressed by an equation (5), (6).

$$E(j) = \frac{P_{pv}(j) - P_{pv}(j-1)}{V_{pv}(j) - V_{pv}(j-1)} \qquad \text{---------- (5)}$$

$$CE(j) = \text{E}(j) - \text{E}(j-1) \qquad \text{---------- (6)}$$

Where Ppv, Vpv tend to be your PV power and also voltage separately in instantaneous j. E (j) shows no matter whether The stress managing point for the instant j is usually located for the left or for the suitable of an maximum power point towards the P V characteristic in which It is equals to be able to zero with MPP though your change regarding error CE(j) couriers the moving direction involving the particular point. by which the control action duty cycle D obtained for its tracking of an maximum power point by comparing through the saw tooth waveform to help develop the PWM signal to its boost converter The appearance of the rules and facts make possible with non-numeric valves in fuzzy logic applications while for mathematics we will take as numeric valves.

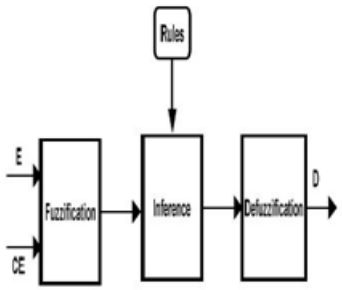

Fig.3 Fuzzy controller diagram

The fuzzy controller design contains the three following steps:

Fuzzification:

The fuzzification may be the method involving converting your own method genuine inputs values E and also CE straight into linguistic fuzzy sets applying fuzzy Logon function.

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these kind of variables are generally expressed regarding five linguistic variables (such Just as ZE (zero), PB (positive big), PS (positive small), NB (negative big), NS (negative small)) utilizing easy fuzzy subsets as viewableRule base & inference engine Parameters control the specific collection that control whether this unsure the valve of the operation technique control of parameters. The technique control algorithm involves the unsure valve of the fuzzy rules throughout listed set in line. The Fuzzy towards the inference contraption can be the running program. The idea formulates a good logical decision based towards the fuzzy rule setting and transforms your current fuzzy rule base in fuzzy linguistic output in the actual paper Mamdani's fuzzy inference method, throughout Max Min operation fuzzy grouping have been used.

Table I. FLC Rules base:

CE E	NB	NS	ZE	PS	PB
NB	NB	NB	NB	NS	ZE
NS	NB	NB	NS	ZE	PS
ZE	NB	NS	ZE	PS	PB
PS	NS	ZE	PB	PB	PB
PB	ZE	PS	PB	PB	PB

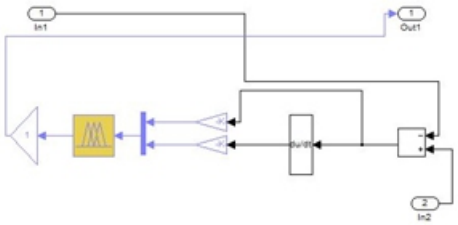

Fig.4 Fuzzy Simulink model

Defuzzification :

Defuzzification of your inference engine, that appraises your rules Based on a set regarding control measures intended for a great released fuzzy inputs set. your procedure changes the inferred fuzzy control exploit in the numerical program code at the output by forming ones union of an outputs resulting by each rule.

one's center associated with location (COA) algorithm will be considered for defuzzification involving output duty control parameter. i.e regardless of whether E is usually NB in addition to CE is actually ZO then crisp D is usually PB, It means that whether ones managing point will be far away with the MPP through the appropriate side, as well as the variation of a slope of a curve is almost Zero, and then increase your current duty cycle.

VII. SIMULATION & RESULTS:

The implemented prototype circuit offers the following parameters: your own input voltage Vi=45 is usually designed for met ones essential specification connected with PV array modular. your own transformer initial winding Np=10(T), secondary winding Ns=27(T),The clamping capacitor Cc along with charge-pump capacitor Cp are generally 10 µF. your own snubber capacitor Cs is usually 0.22 µF. ones output capacitor Co will be 470 µF metal film capacitor. the input inductors Li = Lm are 24 µH. ones small inductor Laux is 150 nH. ones power MOSFET is actually FDP3632.

Pump diode Dp along with clamping diode Dc are Schottky diodes STPS10H100CT. . ones output diode Do is usually fast reverse recovery diode STTH15R06D. the switching frequency is actually harvested on 100 kHz, and also the duty ratios tend to be selected at D1 = 0.25 AND D2 = 0.35 pertaining to switches S1 AS WELL AS S2, respectively. Figure 11 shows your own experiments for the corresponding waveforms for the proposed converter. Your own main button can be operated with absolutely no current stimulated soft switching. the auxiliary switch will be worked in absolutely no voltage turned-on and also –off soft switching with regard to reduced the switching loss of the converter.

During which your output power is actually selected at Po=120(W). Ones measured input along with the corresponding output voltages are generally Vin = 45 (V) along with Vo = 234 (V), respectively. This measured output voltage is Vo = 229.8 (V) that is to be smaller as compared to ones specified output voltage for the coupled coefficient kc in addition to ESR voltage drop for the converter loop. Your own maximum efficiency will be greater than 95%

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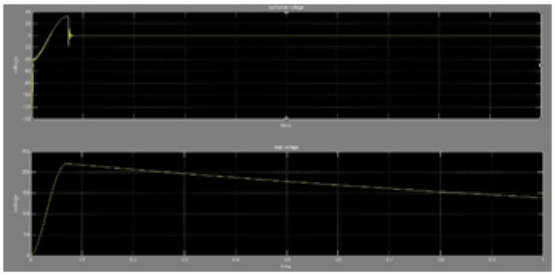

Fig.5 Transformer voltage and load voltage

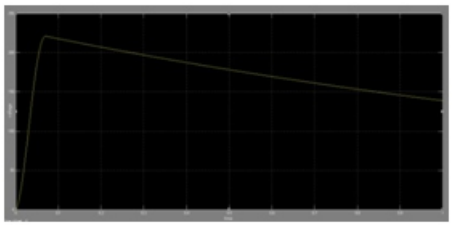

Fig.6 output voltage for existing converter

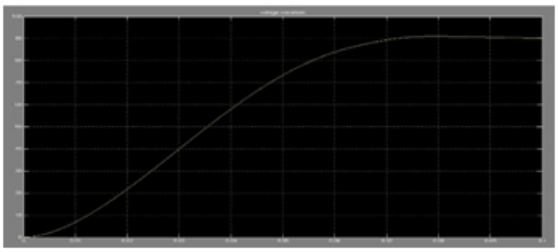

Fig.7 output voltage for proposed converter

VIII. CONCLUSION;

This paper presented a mathematical model for PV. It also included MPPT at varying irradiation and temperature conditions. Boost converter with PI and fuzzy logic controller have been designed and simulated for the proposed PV system, comparison for simulation results have been presented for different irradiation condition.

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