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Multi Photovoltaic Array Buck Boost Single Phase Grid Interconnection with Fuzzy Logic Controller

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ABSTRACT

A single-phase grid connected transformer less photo voltaic (PV) inverter which can operate either in buck or in boost mode, and can extract maximum power simultaneously from two serially connected sub arrays while each of the sub array is facing different environmental conditions, is presented in this paper. As the inverter can operate in buck as well as in boost mode depending on the requirement, the constraint on the minimum number of serially connected solar PV modules that is required to form a subarray is greatly reduced. As a result, power yield from each of the sub array increases when they are exposed to different environmental conditions. In this paper fuzzy logic-controlled buck –boost dc to dc converter for multi PVA system are developed. When the PI controller is replaced by fuzzy logic controller, then the output dc link voltage of buck boost will get improved. General design of a fuzzy logic controller (FLC), based on Matlab/Simulink is performed. This design compared with Proportional Integrated (PI) controller. The complete control system has been developed, analyzed, and validated by simulation study. Performances have then been evaluated in detail for different study conditions.

Keywords: PV Array, MPPT, Buck-Boost Converter, phase lock loop, Three Phase inverter, PI controller, fuzzy logic controller, MATLAB.

INTRODUCTION

Power electronics application broadly includes converters', inverters, choppers etc. The AC to DC converter (rectifier) is one of the most popular power electronics devices which are an efficient and convenient source of DC power. A great portion of electrical and electronic devices currently in use is designed to operate using direct current (DC) power while, for reasons of distribution efficiency, most power is ultimately delivered to such devices as alternating current (AC) power. Therefore, the AC-DC front-end converter is needed to converter the AC power to the DC power in many electrical and electronic devices. Two-stage approach is widely used in the AC-DC front-end converters for high power application. Because of its continuous input current and simplicity, Continuous Conduction Mode (CCM) boost topology is the most popular for the power factor correction (PFC) stage. The major concern of a photo voltaic (PV) system is to ensure optimum performance of individual PV modules in a PV array while the modules are exposed to different environmental conditions arising due to difference in isolation level and/or difference in operating temperature. The presence of mismatch in operating condition of modules significantly reduces the power output from the PV array [1].

The problem with the mismatched environmental conditions (MEC) becomes significant if the number of modules connected in series in a PV array is large. In order to achieve desired magnitude for the input dc link voltage of the inverter of a grid connected transformer less PV system, the requirement of series connected modules becomes high. Therefore, the power output from a grid connected transformer less (GCT) PV system such as single phase GCT (SPGCT) inverter-based systems derived from H-bridge and neutral point clamp (NPC) inverter-based systems [4], get affected significantly during MEC. In order to address the problem arising out of MEC in a PV system, various solutions are reported in the literature. An exhaustive investigation of such techniques has been presented in . Power extraction during MEC can be increased by choosing proper interconnection between PV modules [6], or by tracking global maximum power point (MPP) of PV array by employing complex MPP tracking (MPPT) algorithm . However, these techniques are not effective for low power SPGCT PV system. Similarly, reconfiguration of the PV modules in a PV array by changing the electrical connection of PV modules is not effective for SPGCT PV system due to the considerable increment in component count and escalation in operating complexity. In order to extract maximum power from each PV module during MEC, attempts have been made to control each PV module in a PV array either by having a power electronic equalizer or by interfacing a dc to dc converter Schemes utilizing power electronic equalizer require large component count thereby increasing the cost and operation complexity of the system. The scheme presented in uses generation control circuit (GCC) to operate each PV module at their respective MPP wherein the difference in power between each module is only processed through the GCC.

Scheme presented in uses shunt current compensation of each module as well as series voltage compensation of each PV string in a PV array to enhance power yield during MEC. The schemes based on module integrated converter use dedicated dc to dc converter integrated with each PV module. However, the efficiency of the aforesaid schemes are low due to the involvement of large number of converter stages, and further in these schemes the component count is high and hence they face similar limitations as that of power electronic equalizer-based scheme. Instead of ensuring MPP operation of each and every module, certain number of modules are connected in series to form a string and the so formed strings are then made to operate under MPP in. Even then there is not much reduction in overall component count and control complexity in order to simplify the control configuration and to reduce the component count, schemes reported in combine all the PV modules into two sub arrays, and then each of the sub array is made to operate at their respective MPP. However, the reported overall efficiency of both the schemes are poor. By introducing a buck and boost stage in SPGCT PV inverter, power extraction during MEC is improved in Further, as a consequence of the presence of the intermediate boost stage, the requirement of series connected PV modules in a PV array has become less.

In the schemes presented in the switches of either the dc to dc converter stage or inverter stage operate at high frequency; as a result, there is a considerable reduction in the size of the passive element count, thereby improving the operating efficiency of these schemes. Further, the reported efficiency of and higher than that of. An effort has been made in this paper to divide the PV modules into two serially connected sub arrays and controlling each of the sub array by means of a buck and boost based inverter so that optimum power evacuation from the sub arrays is ascertained during MEC. This process of segregation of input PV array into two sub arrays reduces the number of series connected modules in a sub array almost by half compared to that of the schemes proposed in. The topological structure and control strategy of the proposed inverter ensure that the magnitude of leakage current associated with the PV arrays remains within the permissible limit. Further, the voltage stress across the active devices is reduced almost by half compared to that of the schemes. Hence very high frequency operation without increasing the switching loss is ensured. High frequency operation also leads to the reduction in the size of the passive elements.

II PROPOSED METHODOOGY

2.1 DUAL BUCK-BOOST INVERTER AND ITS OPERATION

The schematic of the proposed Dual Buck & Boost based Inverter (DBBI) which is depicted in Fig 1. V is comprising of a dc to dc converter stage followed by an inverting stage. The dc to dc converter stage has two dc to dc converter segments, CONV1 and CONV2 to service the two sub-arrays, PV1 and PV2 of the solar PV array. The segment, CONV1 is consisting of the self-commutated switches, S1 along with its anti-parallel body diode, D1, S3 along with its anti-parallel body diode, D3, the freewheeling diodes, Df1, Df3 and the filter inductors and capacitors, L1, Cf1, and Co1. Similarly, the segment, CONV2 is consisting of the self-commutated switches, S2 along with its anti-parallel body diode, D2, S4 along with its anti-parallel body diode, D4, the freewheeling diodes, Df2, Df4 and the filter inductors and capacitors, L2, Cf2, and Co2. The inverting stage is consisting of the self-commutated switches, S5, S6, S7, S8, and their corresponding body diodes, D5, D6, D7 and D8 respectively. The inverter stage is interfaced with the grid through the filter inductor, Lg. The PV array to the ground parasitic capacitance is modeled by the two capacitors, Cpv1 and Cpv2.

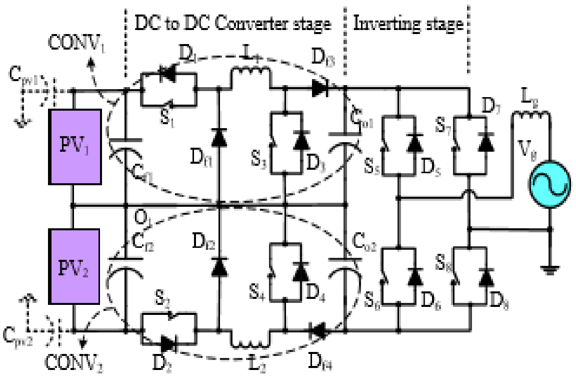

Fig. 1: Dual Buck & Boost based Inverter (DBBI).

2.2PROPORTIONAL-INTEGRAL CONTROL SYSTEM

Proportional-integral-derivative controllers find wide application in industrial control systems due to the reduced number of parameters to be tuned. They also provide control signals that are proportional to the error between the reference signal and the actual output i.e. proportional action, to the integral of the error i.e. integral action and to the derivative of the error i.e. derivative action [13]. The consequent equation is given as:

$$u(t) = K_p e(t) + K_i \int_0^t e(t)dt + K_d \frac{d}{dt} e(t) \quad (2.1)$$

2.2 FUZZY LOGIC CONTROLLER

The fuzzy controller has four main components: The rule-base, which holds the knowledge, in the form of a set of rules, describing the best way to control a system. The membership functions are used to quantify knowledge. The inference mechanism evaluates which control rules are relevant at the current time and then decides what input of the plant should be enabled. The fuzzification interface modifies the inputs, so that they can be interpreted and compared to the rules in the rule-base. The defuzzification interface transforms the conclusions reached by the inference mechanism into the inputs of the plant.

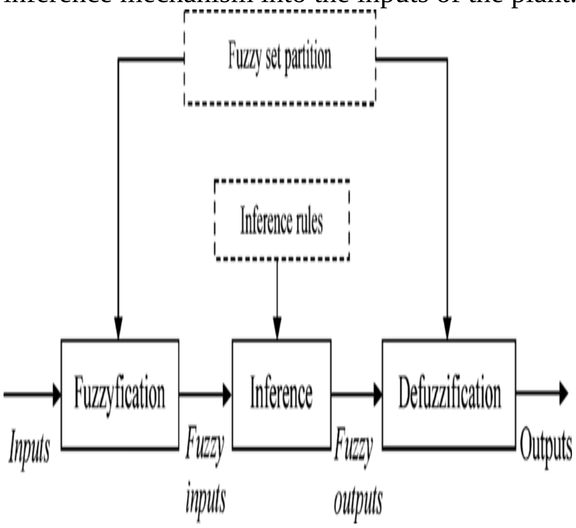

Fig. 2: Control structure of Fuzzy Logic controller.

Advantage of Fuzzy Logic Controller

- Fuzzy logic is cheaper than developing the model-based PI controller in terms of performance.
- Fuzzy logic is more robust than PI controller.
- Fuzzy logic are most customizable
- Emulate human deductive thinking.
- FLC is more reliable than PI controller.
- Fuzzy logic is provides more efficiency when applied in control system

III SIMULATIONRESULT AND DISCUSSION

The complete design related to the project is created in MATLAB& Simulation using Sim Power System Toolbox and thereby analysis the different solar radiation. This designing is conducted in two stages: -

1. Two PVA Buck boost converter single phase grid connected inverter with PI controller.
2. Two PVA Buck boost converter with single phase grid connected inverter with fuzzy logic controller.

3.1 SIMULATION PARAMETER

PARAMETERS	VALUES
Irradiation	1000 W/m^2
Temperature constant	35° C
Inductance L1 and L2	0.6 mH
Capacitance Co1 and Co2	0.5mH
Ac voltage source	220V
Frequency	50HZ
PWM switching frequency	1000
Duty cycle	0.5
MPPT algorithm	Incremental conductance
PI controller	10 and 0.05

3.2 when Two PVA Buck boost converter single phase grid connected inverter.

The proposed inverter a PV array consisting of two PV subarrays while each of the subarray having four series connected modules considered. The MPPT parameters of each are as follows: Vpv1 = Vpv2 = 107 V, Ipv1 = Ipv2 = 10 A and Ppv1 = Ppv2 = 1070 W. The parameters which are used to simulate the proposed inverter are indicated in Table I. MatlabSimulink platform is utilized to simulate the performance of the proposed inverter.

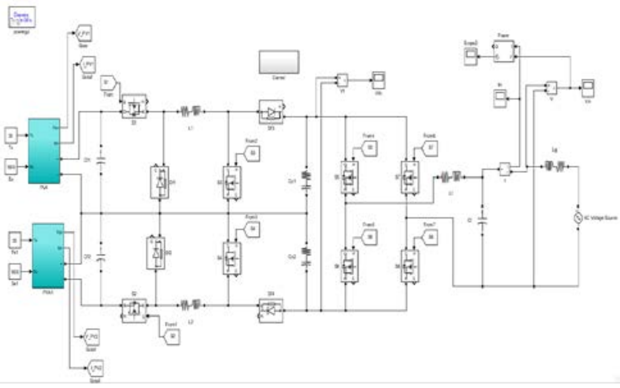

Fig. 3: Two PVA Buck-Boost converter single phase grid.

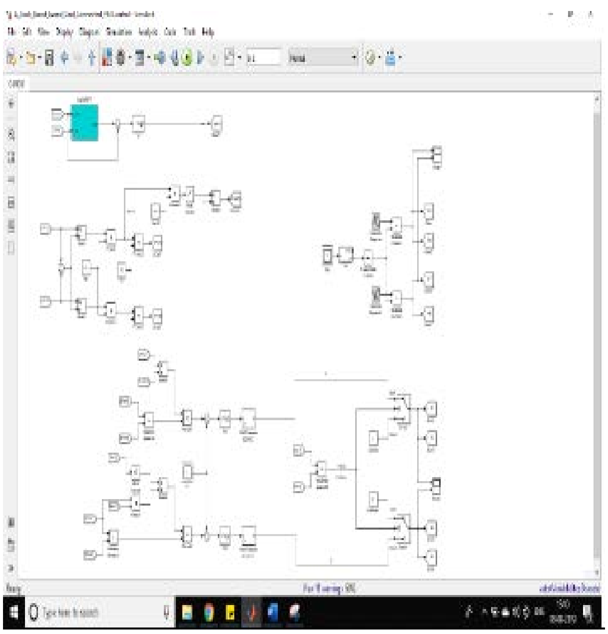

Fig. 4: Control structure of buck boost converter and single-phase inverter.

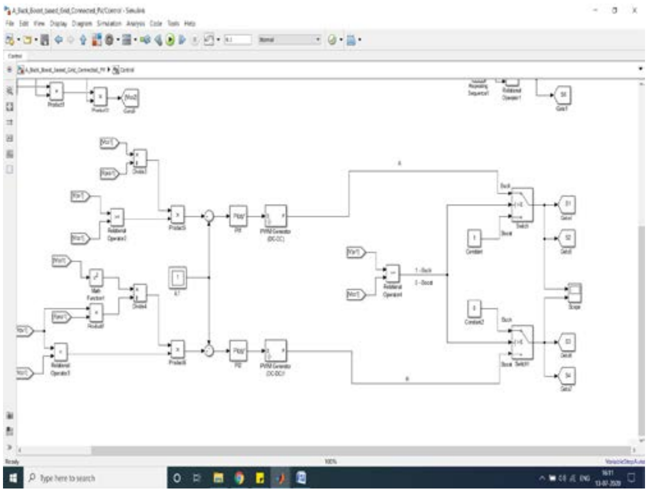

Fig. 5: DC voltage control with PI controller.

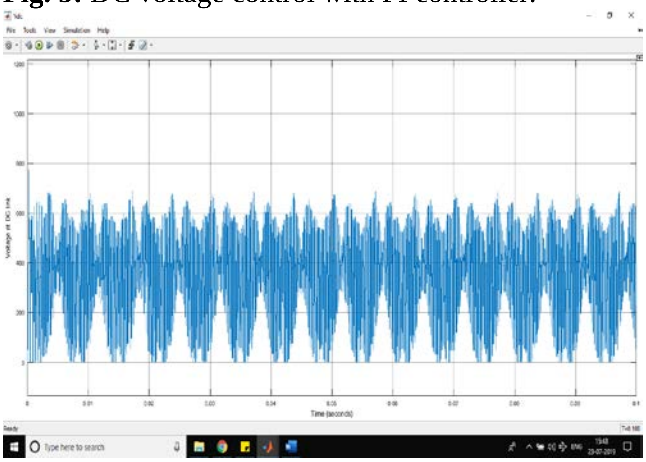

Fig. 6: DC voltage output of buck boost converter.

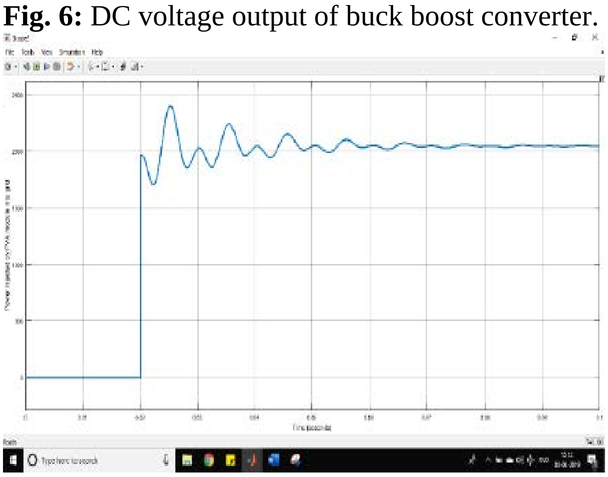

Fig. 7: Power injection from PVA to grid of single-phase inverter.

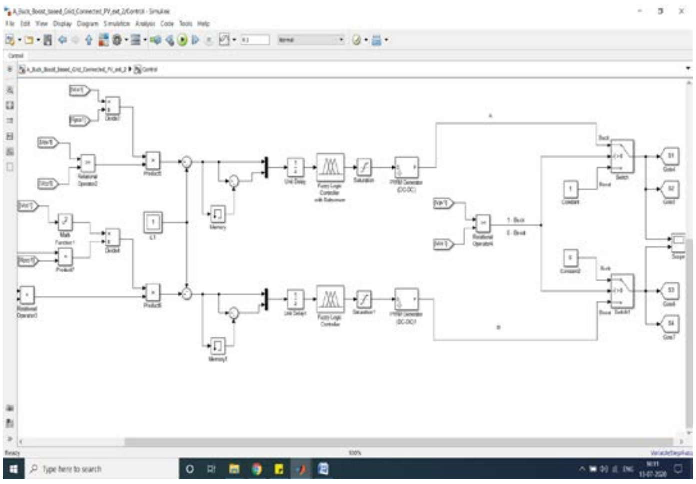

Fig 8: DC voltage control with Fuzzy controller.

3.3 DC link voltage comparison for PI and fuzzy control systems

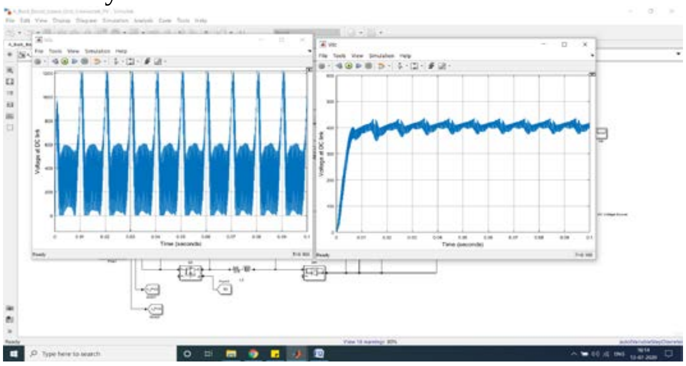

Fig. 9: DC link voltage comparison for PI and fuzzy control systems.

From Fig. no. 9 With the use of fuzzy controller replacing PI controller the DC link voltage is more stable and has reduced ripple. The voltage amplitude is maintained at 400V for the fuzzy logic controlling with limiting the duty ratio by the output membership functions of fuzzy interface structure

IV CONCLUSION

A single-phase grid connected transformer less buck and boost based PV inverter which can operate two sub arrays at their respective MPPT was proposed in my thesis. Here two pv sub array are two different located so that output should be maintain in the power injection from three phase inverter is more stable compared to single phase inverter and also the power injected is more for three phase inverters. Single phase power is 2kW and three phase inverter power is 2.8kW.With the use of fuzzy controller replacing PI controller the DC link voltage is more stable and has reduced ripple. The voltage amplitude is maintained at 400V for the fuzzy logic controlling with limiting the duty ratio by the output membership functions of fuzzy interface structure.

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