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Solar photovoltaic array based brushless DC motor drive using DC-DC converter configuration

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ABSTRACT

A dual output buck-boost (DOBB) DC-DC converter is proposed for solar photovoltaic (SPV) array using permanent magnet brushless DC (BLDC) motor drive. To design a DOBB converter with suitable voltage control, DC-DC boost and buck converters are cascaded such that it accomplishes the purpose of maximum power point tracking (MPPT) and soft starting of BLDC motor. The DOBB converter exhibit the advantages about both the buck and boost converters and gives solution to the problem associated with these converters in SPV applications. The good switch utilization, high efficiency, non-inverting output voltage and low stress on power devices are the features of DOBB converter. In DOBB converter consists of balancing capacitor so steady state performances can be maintained under varying atmospheric conditions and examines the effectiveness of the BLDC motor from SPV array. Instead of B6 inverter B4 inverter are used so that switching losses can be reduced. The performance of projected drive is simulated in MATLAB/SIMULINK atmosphere.

INTRODUCTION

Solar photovoltaic (SPV)[1] energy has emerged as an alternative source of electricity generation having number of advantages. A three-phase induction motors (IM) is widely used in SPV array because of its reliability, low cost and low maintenance requirement .A DC motor is also used in, but owing to a high maintenance requirement caused by the presence of brushes and commutators. When there is no brush then the motor exhibits number of benefits such as high efficiency, long life, high reliability, low radio frequency interference and noise and no maintenance.

A DC-DC converter is commonly placed between the SPV array and VSI (voltage source inverter) fed BLDC motor in order to track the optimum point of SPV array using maximum power point tracking (MPPT) technique [2]. Non-isolated DC-DC buck, boost, buck-boost, cuk and

SEPIC (Single Ended Primary Inductor Converter) used for MPPT[3] in SPV applications are reviewed and compared in and concluded that a buck-boost converter is best suited for SPV system.

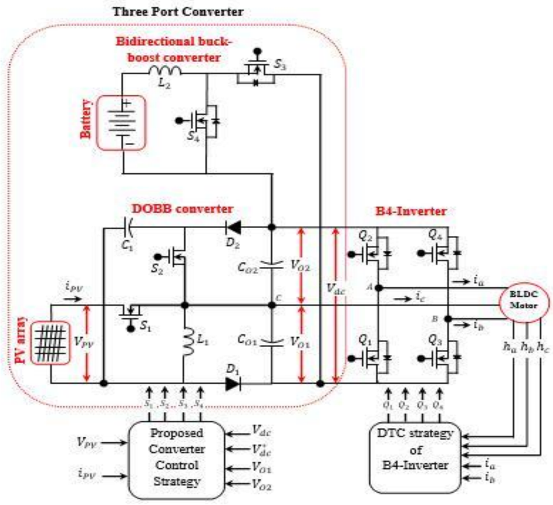
Aggregating the advantages of the boost and buck converter such as good switch utilization, high efficiency, non-inverting input and output voltage and low stress on power devices. A double-switch buck-boost converter is employed for the front stage of the two-stage SPV grid-connected inverter.

The placement of the boost converter at the front end of buck converter and output of SPV array makes the input current continuous because the input inductor of the boost converter works as a ripple filter[10]. Secondly, the placement of the buck converter at back end of the boost converter they exhibits continuous output current and soft starting of BLDC motor[5]. The BB converter is always operated in continuous conduction mode to reduce the stresses on the devices and components. The proposed DOBB converter operating as a non-inverting buck-boost converter also provide an additional feature of middle stage voltage control of the boost and buck converter. Instead of B6 inverter[4] here B4 inverter is used so that switching losses are also reduced.

The starting, dynamic and steady state performances of an electronically commutated BLDC motor[6] coupled with SPV array –DOBB converter are analysed under the variation of atmospheric condition through simulated results using MATLAB/Simulink and experimental validation.

MATERIAL IN METHODS

The block diagram of the proposed converter be given as



From these block diagram the circuit can be classified into four parts namely PV array, DOBB converter, B4-inverter [8] and battery. The rating of the components can be given in the table

S.No	OBJECT	Value
1	Open circuit voltage	22.61V
2	Short circuit current	4.51A
3	Maximum PV module voltage	18V
4	Maximum PV module current	4.17
5	Maximum PV module power	75W
6	Rated power of BLDC motor	39W
7	Rated torque of BLDC motor	0.125Nm
8	Rated speed of BLDC motor	2800Rpm
9	Nominal voltage of battery	24V
10	Nominal current of battery	7Ah
11	Nominal power of battery	168 W/h

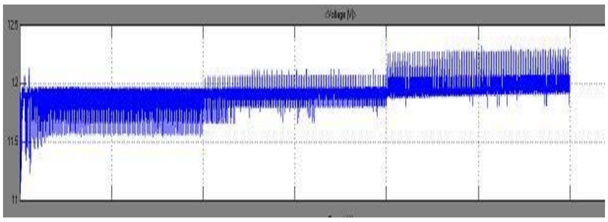
effects on insolation variation condition. The control scheme is realized by dsPIC30F4011, MSP432P401R.Thebelow parameters like ITPC output voltages (1 2), ITPC output currents
(1 2), stator voltage ( ), stator current ( ), battery voltage ( ) and battery current ( ) of the system are measured for the validation of the proposed
concept

Here there are two operating mode i.e battery charging and battery discharging. These of operation depends on the irradiation on the solar photovoltaic array.

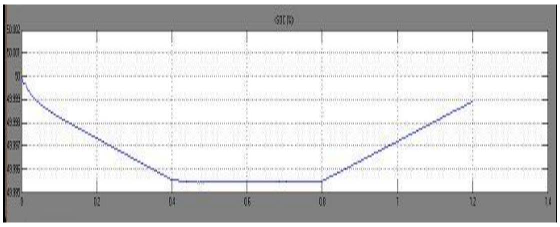
The BLDC motor is used as the load which has the power rating of about 39W.the motor supplies 40W of mechanical power to a load from B4 inverter at the speed of 2800 Rpm.

RESULTS AND DISCUSSION

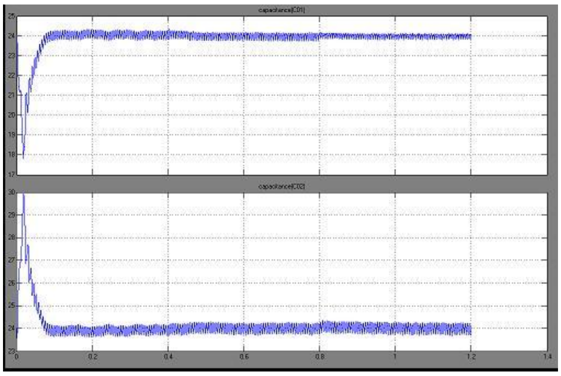
Simulation design has been done for the proposed system and the simulation result be



Voltage for the proposed converter



State of conversion for battery



Output voltage of capacitance (CO1, CO2)

CONCLUSION

The DC-DC boost-buck converter for SPV array fed BLDC motor driven has been proposed. The complete system has been designed, modelled and simulated in MATLAB/Simulink environment and implemented on a developed hardware prototype. Utilizing all the properties of both the boost and buck converters and connecting these two converters in an appropriate manner, a new BB converter with the low valued components has been designed and operated in CCM. Working as a non-inverting buck-boost converter[9], the proposed BB converter has eliminated the drawbacks of the buck, boost and topologies of buck-boost converters used in SPV based applications. Even at the minimum solar insolation level also motor operated at the rated value with the help of battery power. Moreover, fundamental frequency switching of the VSI has avoided the high frequency switching losses. The presented simulation and experimental performances of the proposed system at starting, dynamic and steady state have proven.

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