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A Performance of a Novel Three Port Converter for Solar PV Storage Systems

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***Abstract:** This research work is generally emphasize to show and estimate the performance of a new three port converter by connecting a a battery port ,PV port, and also load port all collectively connect in a power system then a original three port converter named bidirectional buck with buck boost converter is projected. The chief advantage of the proposed converter topology is the one-stage power conversion which improve the overall success of the converter. The presentation of the proposed system is simulated in MATLAB and its efficiency based on overall module count, losses and competency is evaluated. Finally to validate the performance of the proposed converter, it is compared with other conservative converters and the evaluation results confirm the dynamic performance of the proposed system. The comparison of various power converters with MPPT technique are made and the simulation result proves the necessity of a suitable converter to be accepted for tracking the highest PowerPoint in solar PV systems.*

***Keywords :** PV Powered Storage systems, Bidirectional Power Flow Management, Performance Analysis, Single Stage Power Conversion, Three Port Converter, Maximum power point.*

I. INTRODUCTION

The fast change in global energy stress and the environmental problems caused by fossil fuels have resulted in the need of solar energy which becomes a potential solution and one among the most accepted renewable energy sources. Solar power is utilized in areas where standard power supply is not available. The recent tendency is to focus on the PV battery powered backup system [11] in order to meet the required load demand. In such cases, an efficient converter is necessary to maintain the power demand within the limit of the maximum availability and also to prevent other failures. Onwuchekwa & Kwasinski [10] presented a new, and simple approach based on buck-boost converter topology. But, the proposed converter has a non-uniform power flow path between battery and load port when the battery is connected for charging and discharging. So, this system is not appropriate for a PV-battery backup structure.

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Chen & Yen-Mo et al. [2] presented a novel boost converter with high voltage gain based on the technique of three stable communication cell. To spot a appropriate power converter for track the MPP, an study of MPPT based power converters has been approved out.

Nowadays the solar systems are in progress of better implication as a renewable resource due to its reward like less fuel cost, maintenance free and less noise and moving parts etc. Still, there are some fundamental difficulties to use the solar systems such as the cost of installation is tall, the energy conversion and tracking efficiency is less due to its transfer stages. Hence, by implementing this model a DC bus along with a PV panel array is used. This permits the batteries to charge at the same time based on the strength of solar radiation. But it was establish that the plan of proposed system was hard due to additional number of semiconductor power devices used in the system. The conduction losses taking place during battery charging and discharging bidirectional buck with buck boost converter (B4C) is projected. Then the proposed topology is used for interfacing a battery port, a PV port and a load port concurrently in a power system. The active performance of proposed converter is evaluated based on three domain distribution control method are more and hence the ability of higher efficiency is difficult. To reduce these problems,[15] a novel single stage three port DC/DC converter named boost bidirectional buck with buck boost converter (B4C) is proposed. Then the proposed topology is used for interfacing a battery port, a PV port and a load port simultaneously in a power system. Finally a requirement of suitable converter is identified in order to harvest the maximum power from the solar panel [13]. The simulation result of proposed system proves the requisite of a suitable converter.

II. PROPOSED METHODOLOGY

The schematic diagram of proposed converter is given in Fig 1. It chiefly consists of boost converter and bidirectional buck with buck boost converter (B3C). Here, (L1), the input inductor (D1) diode and switch (S1) for extracting the maximum power from PV panel boost converter is utilized also by making use of maximum power point tracking (MPPT) algorithm [7].

In adding, the proposed converter arrangement consists of buck boost inductor (L2) diode (D2), switch (S2), buck inductor (L3), battery powered backup supply and output capacitor (C0).Here, the converter-B4C is occupied for maintaining the stable output voltage (VL) arising due to difference between the demand and production . When the command goes away from than generation, then (VL) drops from its base value, later battery will discharge in order to offer for the extra demand.

Just like that, when the demand is smaller than generation, (VL) increases over its base value, and then as a result the battery will charge in order to attract the added power.
The Buck–boost converter is utilized as a bidirectional converter for the reason of enabling the robust power flow between load and battery [12]. The conventional converters are compared with proposed system topology in the aspect of tracking time and tracking efficiency, also quantity of devices used.

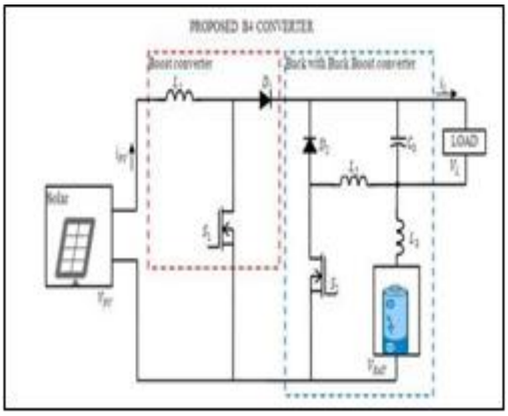

Fig.1: Proposed B4 Converter

The main advantages of this proposed converter are as follows a) Current is in irregular conduction mode for refining the life of the battery. b) Due to the single-stage power conversion technique the efficacy of the converter gets better. c) The converter is designed with least number of components [5,6] to reduce the the current conduction and average losses .

III. SIMULATION OF PROPOSED B4 CONVERTER

The performance of the proposed system is designed using a matlab / Simulink environment also make use of the Sim Power-System Toolbox. Under dynamic solar irradiation conditions [13] the projected converter presentation is analyzed. The Parameters like Panel power(P_{PV}), Load power(P_L), Battery power(P_{BAT}), Load voltage(V_L), then (i_{L1}), (i_{L2})and(i_{L3})current flowing through the inductors, and then state of charge in the battery (SOC) of the proposed converter are assess in order to prove its proper implementation. The input and output specifications of the proposed converter are given in Table 1. The Fig 2 indicates the simulation diagram of proposed converter.

Table1. B4 Converter specifications

Parameter	value
180W PV panel design specification Short circuit current at reference condition Isc Open circuit voltage at reference condition Voc	5.48 A
MPP voltage at reference condition Vmp MPP current at reference condition Imp Series resistance Rs	43.6 V
Irradiance at standard test conditions (STC) Cell temperature at standard test conditions	35.8 V
Maximum power @ STC	5.03 A 0.113 3 1000 W/m2 25 _C 180W

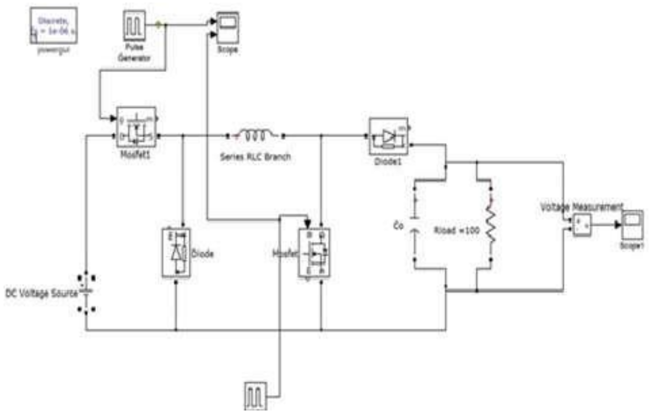

Fig. 2: Simulation diagram of converter B4C

The proposed converter simulation circuit and also The output voltage of B4 converter is shown in Fig.2 and in Fig 3 respectively. From the Fig 3 it is observed that the voltage of the converter is not constant and also it must be stabilized by adding a suitable controller.
Then the proposed topology is used for interfacing a battery port, a PV port and a load port simultaneously in a power system. Finally a requirement of suitable converter is identified in order to harvest the maximum power from the solar panel [13]. The simulation result of proposed system proves the requisite of a suitable converter.

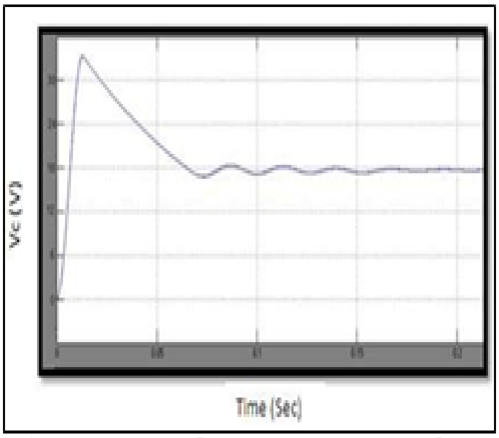

Fig. 3: Proposed converter output voltage

The performance comparison analysis of the suitable proposed converter is carried out 1) In terms of current Losses and efficiency 2) In terms of tracking time and tracking efficiency presented in the next Chapter.

IV. COMPARATIVE PERFORMANCE ANALYSIS OF B4C

a). In terms of Efficiency and Average losses

The proposed converter is compared with other normal converters they are boost bidirectional buck converter , conventional Single Ended Primary Inductance Converter (SEPIC) and ZETA converter [9] in the aspect of efficiency, less number of semiconductor power devices used and current conduction and average losses. The relative analysis is indicated in Table 2. From the Table 2, it is obvious that the proposed converter performance is superior in the aspect of efficiency, component count and average losses, while compared with other converters [1,4].

b). In terms of Tracking Efficiency and Tracking Time

The efficiency of the solar panel is mostly calculated by the energy conversion efficiency of and also the conditions which are control the efficiency are such as climate, the level of irradiation and hotness. The operating point of the system will be at the intersection of the I–V curves of the load and the solar pv panel, when a PV array is straightly connected to a load [5,10]. The MPPT is implemented in order to acquire the maximum power from a PV array and the position of the MPP is not known well in advance. So it can be calculated using a PV array model, amount of irradiance and array temperature and the MPPT must constantly hunt for the MPP of the solar PV array. To follow the maximum power from solar PV array, many algorithms have been proposed. the Perturb And Observe method was used by the proposed converter to track the MPP in its control strategy.

Table 2.Comparitive Performance Analysis of B4C in terms of Average losses and Efficiency

Converter type	Total No of devices used	Average losses	% Efficiency
Conventiona l B3C	11	53.7	94.2
Conventiona l SEPIC	12*	56.5	91.4
ZETA converter	8*	52.6	93.2
Proposed B4C	8	43.6	97.3

In this method there is a perturbation in the duty cycle ratio of the proposed converter and PAO includes a perturbation in the solar array operating voltage [7]. If a PV array is connected to a power converter, then the duty ratio of power converter is disturb also the current of PV array and subsequently perturbs the voltage of PV array. An increase or decrease in the voltage increases or decreases the power when working on the left of the MPP and the power is decreased or increased while operating on the right side of the MPP. So if power is improved and the resulting perturbation must be reserved at the same value in order to attain the MPP and if the power is decreased then

the perturbation must be inverted [8,15].The summary of PAO Algorithm is indicated in Table 3.

While implementing the algorithm a small perturbation of ΔD = 0.01 is introduced in the system. Then the power of the solar

Table 3. Summary of PAO Algorithm

Perturbation	Change in Power	Next Perturbation
Positive	Positive	Positive
Positive	Negative	Negative
Negative	Positive	Negative
Negative	Negative	Positive

module is also changed due to the perturbation. If the power increases due to perturbation, then the perturbation is sustained in the D+ΔD direction till the peak power is reached whereas if the power at the next instance is decreased then the perturbation is sustained in the direction of D-ΔD. The various power converters used in solar PV system for MPPT with PAO algorithm are analyzed, in the aspect of their maximum tracking power and efficiency [15]. A comparative analysis was made between various conventional converters such as SEPIC, ZETA and B3 converter for tracking the maximum power and the parameters are listed in Table 4.

From the Table 4. it is observed that the suitability of various conventional converters for MPPT with PAO technique. Their comparative analysis indicates all the conventional converters have a tracking efficiency of around 97% with equal tracking time of 0.9011 hours. Also the assessment results prove the condition of a suitable power converter with superior tracking efficiency and improved tracking time to be recognized and which is robust for solar PV powered backup systems. From the Table 4, the proposed converter has enhanced tracking efficiency of 99.07% with a tracking time of (0.9011hours or 54 minutes).While compared with other converters, the proposed converter obtained a utmost tracking efficiency of 99.07 % with the same tracking time and working conditions. It shows the aptness of the identified converter for tracking purpose and the maximum power points are perfectly reached here.

Table 4. Comparative Performance Analysis of B4C in terms of tracking Efficiency and time

Parameters	**SEPIC**	**ZETA Converter**	**B3 Converter**
Maximum Power (Pmax) (W)	135.96	135.55	136.37
Maximum Voltage (Vmp)	34.6	34.5	34.7
Maximum Current (Imp) (A)	4.2	4.2	4.2
Tracking Energy (Wh)	1585.75	1581.014	1590.48
Theoretical Energy (Wh)	1631.23	1631.23	1631.23

Tracking Efficiency (%)	97.37	97.09	97.64
Tracking Time of MPP (hours)	0.9011	0.9011	0.9011
Tracking Time of MPP(min)	54	54	54

At last, a necessity of proper converter with superior tracking efficiency was identified which is very much suitable for MPPT. The simulation results of proposed converter with PAO mppt Algorithm at various irradiance levels is indicated in the Fig .4. The performance analysis of a B4 converter for MPPT, using PAO algorithm was presented.

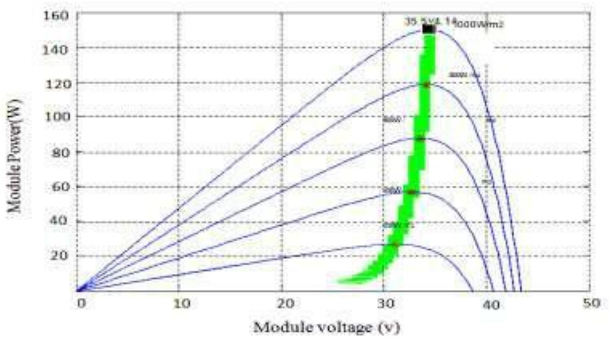

Fig 4. PAO Algorithm based P-V curves at various Irradiance levels

The simulation results of converter were compared with other conventional converters in the aspect of tracking time and tracking efficiency. The comparison result shows the well appropriateness of the converter for tracking MPP in solar applications. still the proposed system works properly, but the output of constant power of solar array.

V. CONCLUSION

This proposed work presents a comparative performance analysis of a new three port converter, in order to prove and assess the dynamic performance of the proposed system. The proposed topology produces enhanced performance in component count, efficiency and average current conduction losses when compared with other converters and it is obvious that the proposed converter performance is superior when compared with other conventional converters. The proposed system topology can be applied in several applications such as PV powered backup system, electric vehicles, street light, micro inverter system, and so on.

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