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Comparison of Solar Powerd SEPIC, ZETA and ILBC Converters Fed DC Drives

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Abstract

Extracting solar power from the solar cell with high efficiency is a challenge. A best boost converter can be employed to do the above mention process. In order to find a best converter with better efficiency, comparison of solar powered SEPIC, ZETA and three switches ILBC fed DC drive systems is done. Three above mentioned converters are designed, modeled, and simulated. The simulation results are compared in terms of output power, speed and voltage ripple. The interleaved boost c converters are advantageous over reduced ripple, higher output power and hence improved efficiency. The simulations are done with MATLAB/SIMULINK and the results are exhibited.

Keywords: DC Drive, Interleaved Converter, SEPIC Converter, ZETA Converter

1. Introduction

The Renewable energy is the only solution to meet the present energy crisis. Among them, solar energy is the best energy that can be employed without environmental contamination and maintenance free[1]. Though, PV energy has some limitations like high capitation cost and low conversion efficiency, it has grasped the attention of the researchers.

Solar energy PV panel is a nonlinear device. In order to extract the maximum power from the PV panel a Boost converter can be employed between the PV panel and the load shown in Figure 1. By adjusting the duty ratio of the converter, maximum power can be achieved from the PV panel[2]. But, the energy generated by the system is very low. In order to overcome, the aforementioned disadvantage in the PV system the DC/DC boost converter is employed in between the power generation stage and the load to boost the voltage obtained.

Our conventional power converters have low efficiency due to the poor conversion ratio. The semiconductor devices are used as the switch in the converter. Since, these switches suffer with voltage stress, the switching losses increases and efficiency is decreased. These switching losses can be rectified by using soft switching technique[3]. Soft switching can be achieved by smoothing the current by applying an additional inductor. The ripples in the output can be reduced by interleaved PWM pulses. In order to increase the conversion ratio Zero Voltage Switching (ZVS) and Zero Current Switching (ZCS) technique can be employed in addition to be increased further. Moreover, closed loop control provides better dynamic response and voltage regulation[3].

Power converters with high efficiency are required. The high efficiency can be achieved by reducing the switching losses, reducing input current and output voltage ripples. So, there is a high demand for finding out a best and suitable converter for every system depending on their load demands and requirements.

Since, SEPIC converter can be used in various applications such as LED head lights for auto mobile. Where, the brightness of the light can be controlled using the converter and power can used efficiently. SEPIC converter can be used in SMPS, low power equipment and high quality input power[4].

This work involves in identification of suitable converter to boost the solar voltage to the required level. We have compared the solar powered SEPIC, ZETA and three switch ILBC converter circuits.

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Figure 1. Block Diagram.

2. Simulataion of Sepic and Zeta Converters

The modelling and simulation of the circuit is done with MATLAB/Simpower systems.

2.1 SEPIC Converter System

The solar powered SEPIC converter system with R load is shown in Figure 2. A SEPIC converter is connected to boost up the power rating and reduce the ripple in the output[5,6]. The PV cell is used as the input source and the output voltage of the PV cell is shown in Figure 3. The output voltage of the PV cell is 48.76V which is given as the input to the SEPIC converter. The output voltage is 200V and the output current is 80A. The output voltage and output current are displayed and shown in Figure 4 & Figure 5. The output voltage ripple is shown in Figure 6.

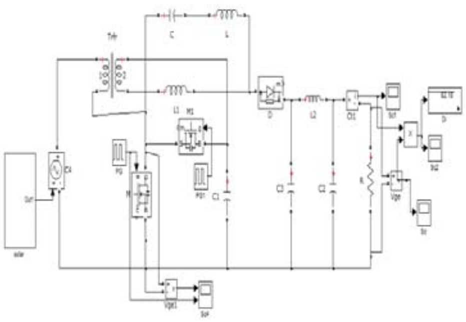

Figure 2. SEPIC converter.

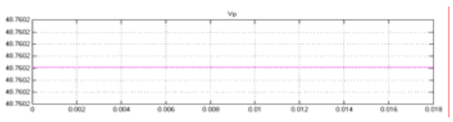

Figure 3. Solar output voltage.

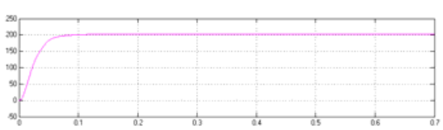

Figure 4. Output voltage of SEPIC converter.

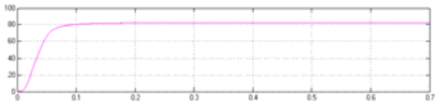

Figure 5. Output current of SEPIC converter.

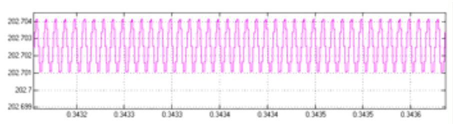

Figure 6. Output voltage Ripple of SEPIC Converter.

2.2 ZETA Converter System

The Solar powered ZETA converter system with R load is shown in Figure 7. The output voltage of the PV cell is 48.76V which is given as the input to the ZETA converter. The output voltage is 80V and the output current is 14A. The output voltage and output current are displayed and shown in Figure 8 & Figure 9. The output voltage ripple is shown in Figure 10.

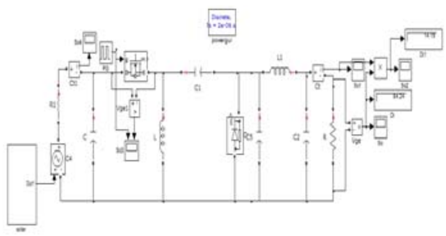

Figure 7. ZETA converter.

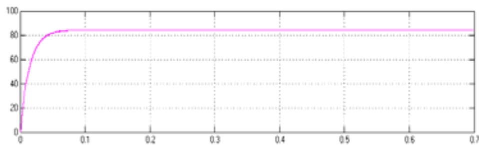

Figure 8. Output voltage of ZETA converter.

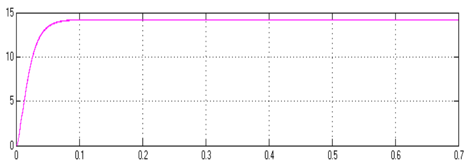

Figure 9. Output current of ZETA converter.

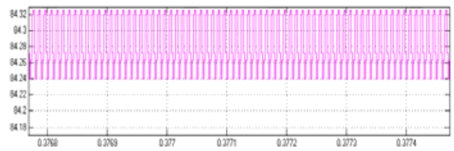

Figure 10. Output voltage Ripple of ZETA Converter.

3. Simulation Results of Interleaved Converters

The modelling and simulation of the circuit is done with MATLAB/Simpower systems.

3.1 Interleaved SEPIC Converter System

The solar powered interleaved SEPIC converter system with motor load is shown in Figure 11. Two SEPIC converters are connected in Parallel-Parallel fashion to boost up the power rating and reduce the ripple in the output. DC motor is fed by the cascaded converters. The speed and torque of the motor are measured and displayed. The PV cell is used as the input source and the output voltage of the PV cell is shown in Figure 12.

The output voltage is 48.76V. The speed increases initially and settles at 1110rpm as shown in Figure 13. The torque settles at 0.5NM as shown in Figure 14.

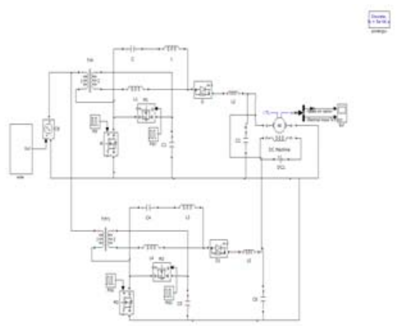

Figure 11. IL Sepic converter with motor load.

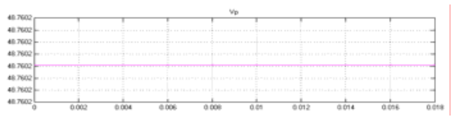

Figure 12. Output voltage of PV system.

Figure 13. Motor speed.

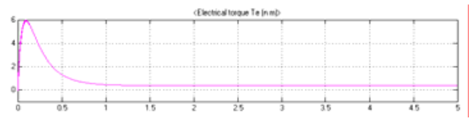

Figure 14. Torque.

3.2 Interleaved ZETA Converter System

The Simulink model of interleaved ZETA converter system with DC motor load is shown in Figure 15. The speed response curve is shown in Figure 16. The speed of the drive settles at 1150 rpm. The Torque response is shown in Figure 17 and its value is 0.5Nm.

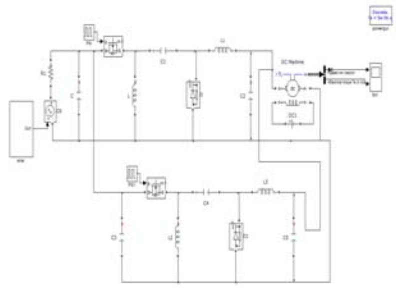

Figure 15. IL Zeta converter with motor load.

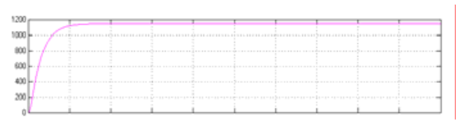

Figure 16. Motor speed.

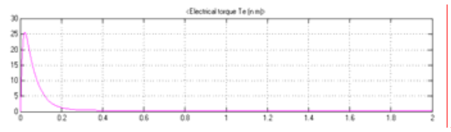

Figure 17. Torque.

3.3 Interleaved Boost Converter System

The ILBC fed DC drive with three switches are shown in Figure 18. The Pulses given to the switches are shifted by 120^0. The output of the solar cell is shown in Figure 12. The speed response curve is shown in Figure 19. The speed settles at 3270 rpm. The torque response curve is shown in Figure 20. The torque settles at 1 Nm.

The summary of results of various converters is given in the Table 1 and Table 2. From Table 1 it can be observed that ILBC has reduced ripple than other converters. It can be seen from Table 2 that the ILBC system produces higher mechanical output than other systems and ILBC has reduced output ripple than other converters.

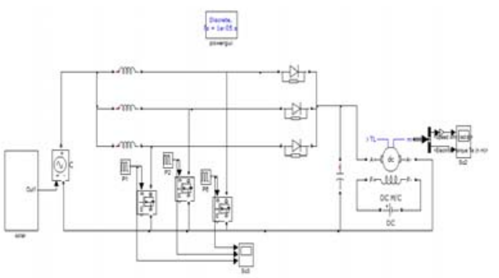

Figure 18. Interleaved boost converter.

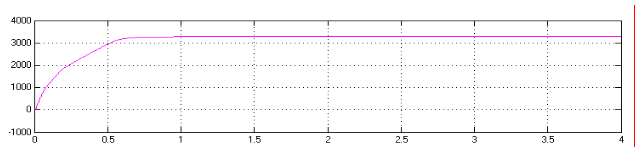

Figure 19. Motor seed.

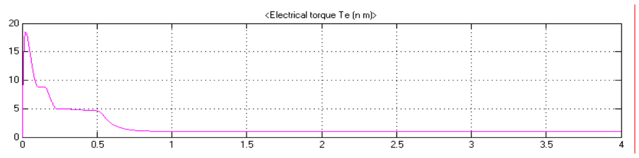

Figure 20. Torque.

Table 1. Comparison converters for output Ripple

Input Voltage	Type of converter	Output voltage	Output Power
48 V	SEPIC	0.003	82 W
48 V	ZETA	0.08	14 W
48 V	Interleaved	0.0001	172 W

Table 2. Comparison of speed for various systems

Input Voltage	Type of converter	Speed of the Motor (RPM)
48 V	SEPIC	1110 RPM
48 V	ZETA	1150 RPM
48 V	Interleaved	3270 RPM

4. Conclusion

IL ZETA, SEPIC and ILBC fed drive systems are compared and the results are tabulated. The results ensure that the ILBC fed DC drive gives better performance compared to the other drives systems. The simulation results done by MATLAB/Simulink software are in line with predictions. The ILBC fed DC drive systems has some advantages over than other systems like reduced ripple, higher output power and improved commutation ability. The disadvantages of the ILBC fed drives are additional switches and diodes.

5. References

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