A NEW Z-SOURCE INVERTER FOR APPLICATION IN WIND ENERGY CONVERSION SYSTEM

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ABSTRACT:

Increase in the demand of renewable energy sources has resulted into the boosting of demand of wind energy generating systems. The intermittent nature of wind energy has driven many researchers to focus on the power electronic converters for suitable interfacing with the conventional loads. The conventional AC loads must be supplied with quality power in order to increase the longevity of the electrical equipment. Development of improved converters are focused from many years however, the performance of Z-source inverters (ZSI) over other power converters have created a motivation to today’s researchers to concentrate on ZSI based wind energy conversion system. This paper focuses on the design and implementation of an improved ZSI which uses lesser number of switches compared to the conventional ZSI. Also, the converter is able to deliver a constant voltage at the output of the inverter in order to operate the generator smoothly which is linked at the output terminals. The proposed converter is simulated using MATLAB/SIMULINK and the obtained outcomes are furnished in this paper. The efficiency of operation proves the proposed system efficacy.

Keywords: Wind energy conversion system, ZSI, Power electronic converter, Renewable energy, Power conversion

Abbreviations: ZSI, Z-source Inverter; WECS, wind energy conversion system; PWM, pulse width modulated; I-ZSI, improved ZSI;

I. INTRODUCTION

Increase in population has led to the increase in dependency on petroleum products. These petroleum products generate poisonous byproducts while operation [1-5]. The increase in global warming has motivated researchers to search for non-conventional energy sources [6]. Among all the non-conventional sources, wind energy has got more focus because of its various advantages [7]. Advantages such as, easy availability, zero operational cost and clean energy generation have increased the demand of wind energy among users [8].
In order to interface the wind power generation system to operate electrical loads, wind energy conversion system (WECS) are implemented [9-15]. These interfacing systems are termed as the power electronic converter [16,17]. Recent years researchers have focused on different pulse width modulated (PWM) converters for WECS [18-22]. The PWM based converters can deliver power from wind generator. However, the variation of wind speed causes the variation in the output power of WECS [23]. The variation output voltage causes in the decrease in the life cycle of the loads connected across the output terminals [24].

![Block diagram of the proposed system](image1)

**Fig. 1.** Block diagram of the proposed system

The proposed converter is an improved ZSI (I-ZSI) which has lesser number switches compared to the conventional ZSI. The inverter is implemented between the rectifier and the load of a WECS. Irrespective of the speed variation of the WECS or the variation of voltage at the output of the rectifier, the proposed ZSI is able to deliver constant voltage at the output terminals.

**II. PROPOSED WECS**

Block diagram of the proposed system is depicted in Fig. 1. The system consists of a WECS, diode bridge rectifier, I-ZSI and the AC Motor.

The WECS system consists of wind energy generator which is able to generate electric power from wind speed. The generated AC voltage from the output of the WECS is fed to the diode bridge rectifier which converts the AC voltage to DC. This DC voltage is converted back to AC by using the I-ZSI. AC motor is connected to the output terminals of the I-ZSI.

**III. OPERATION OF THE I-ZSI**

Schematic diagram of I-ZSI is shown in Fig.2. The inverter consists of two capacitors connected in Z manner. Two inductors are connected in order to reduce the ripples in the input and output current of the inverter.
The inverter operates in two modes:

1. Neutral mode (Non-Shoot through)
2. Power mode (Shoot through mode)

Detailed description of working of the system is provided in the following subsection.

A. Neutral mode

In this mode, the inverter acts as a normal VSI. The equivalent circuit of the inverter during this mode is depicted in Fig. 3.

The input voltage neither get boosted not get bucked in this mode. As the conventional VSI, in this mode the rms value of the output voltage remains same as the average value of the input voltage.

\[ V_{out} = M \cdot V_i / 2 \]  

(1)

Fig. 3. Operation of I-ZSI during neutral mode

Fig. 4. Operation of I-ZSI during power mode
Where,

\( M = \text{Modulation index} \)

\( V_o = \text{Rectifier output voltage} \)

\( V_{out} = \text{Maximum sinusoidal inverter output voltage} \)

**B. Power Mode**

In this mode the inverter acts as a boost converter. Input voltage gets boosted at the output of the converter. The equivalent circuit of the inverter in power mode is depicted in Fig. 4.

The stored charge in the capacitors is discharged through the load during this mode of operation. The output voltage during this mode is as follows:

\[
V_{out} = M \cdot B \cdot V_o / 2
\]

\[ B = \frac{1}{1 - 2(T_0 / T)} \]

Where \( B = \text{Shoot through constant} \)

\( T_0 = \text{Shoot through time} \)

\( T = \text{Period of the supplied voltage} \)

The proposed converter is analyzed and the results are depicted in the following section.

<table>
<thead>
<tr>
<th>Si. no.</th>
<th>Components</th>
<th>Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Inductor</td>
<td>30 μH</td>
</tr>
<tr>
<td>2</td>
<td>Capacitor</td>
<td>90 μF</td>
</tr>
<tr>
<td>3</td>
<td>Switching frequency</td>
<td>10 KHz</td>
</tr>
</tbody>
</table>

**Fig. 5.** Simulation diagram of I-ZSI
In order to implement the proposed system MATLAB/Simulink software is employed and further using the functional blocks available in it. The attained results are discussed in detail in this section. Further, simulation parameters are listed in Table 1. The proposed converter is tuned such a way that it boosts the output voltage during low wind speed and acts as a VSI during high wind speed.

The snapshot of the proposed system and output waveforms are depicted in Fig. 5 and Fig. 6. The standalone passive or active systems are not suitable as well as sustainable owing to the enhancement in demand of energy in the space heating/cooling. It encourages us to utilize appropriate hybrid systems conferring to tailor made scenarios.

**IV. CONCLUSION**

In this paper an improved ZSI is explained. The proposed inverter is experimented using Matlab/Simulink software and the operation of the inverter in different modes is explained. The simulation result shows an efficient AC output. This simulation result proves the efficacy of the system.

**V. FUTURE SCOPE**

The proposed system can be applied with renewable energy sources.

**Conflict of Interest:** There is no conflict of interest.

**REFERENCES**


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