Wind Energy Generation Based for Grid Connected System Using Zeta Converter and Terminal Sliding Mode Control

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Abstract: In this paper, the wind energy system (WES) is interfaced with the grid system using a permanent magnet synchronous generator (PMSG) with robust control of terminal sliding mode controller (SMC) is proposed. In this system, voltage source inverter (VSI) with three phases has connected in grid side using less resistive losses of LCL filter but without using grid connection transformer. The ZETA converter is utilized to develop the voltage of DC link wind system connected rectifier. The high voltage gain is achieved by using the PWM switching signals for the converter. The grid side VSI is used to provide the reliable, efficient and supplying secure with the power, and it is controlled using the control strategy of terminal sliding mode controller (TSM). The proposed system results are verified, and the TSM control’s achievement is based on VSI, which is connected in the grid side validated using MATLAB/Simulink.

Keywords: ZETA converter, WES, TSM, PMSG, LCL filter, and grid power efficiently.

1. Introduction

The inexhaustible sources are sustainable and provide renewable energy such as wind energy conversion system, solar system, hydropower source system, geothermal, rain, waves etc [2]. In the renewable energy sources of power provision, the cheapest source is accomplished through the WES [1]. In the generation of renewable power using wind system, which comprises interconnection apparatus, electrical power generated generator, wind turbine and controller system. In the electrical system power generation, the WES renewable power source is a competitive and reliable [3]. The wind turbine with WES of the variable speed system achieves higher efficiency than the variable speed system. The WES of variable speed system is implemented to generate power in a highly effective manner due to the merits of aerodynamic noise and less stress in mechanical [5].
There are three kinds of electrical generators currently used for the wind system generation, such as PMSG, SCIG, and DFIG. The above-mentioned generators are used in WES based on power ratings. The generator's energy transmission to the connected grid system the PWM-based converters are connected back to the back form [6]. This type of converter is used to achieve high efficiency. It includes the power flowing in bidirectional, unity power factor achievement, and DC link voltage and controllable one. However, wind power generation depends on nature to be intermittent [8]. The WES's critical challenge is to control the conversion power's operation and performance from the generator to the power grid. The controllers are essential to control the converter response to control the power conversion, including accuracy and robustness with efficiency [11]. The control system significantly affects the power conversion from WES to the grid, using the wind system's stability. The PWM-based converter control methods are used to control the power conversion in a conventional system [12]. After that, the vector control is introduced separately to control the active and reactive power in a grid-connected converter system. In this system, the DC link voltage can be controlled using three PI control systems and both currents of d-q axis currents [14]. In grid side converter (GSC), the PI controller is oriented by the voltage in synchronous reference theory to control the computational complexity. The sliding mode control (SMC) is utilized in the grid converter to control the powers [13]. The SMC control is proposed to achieve stability in the operation regions of both non-minimum and minimum phases. In this method, the chattering cannot be eliminated, and SMC is based on switching signals.

In this paper, the terminal sliding mode (TSM) control is proposed to provide switching signals for the power switches in the grid side converter. In this system, voltage source inverter (VSI) with three phases has connected in grid side using less resistive losses of LCL filter but without using grid connection transformer [9]. The ZETA converter is utilized to improve the DC link voltage of the wind system connected rectifier.

2. **Proposed System**

The WES with the grid-connected system is proposed using ZETA converter to better the DC power in the inverter source bus bar of the rectified voltage from the wind farm. The wind energy system generates power using the three-phase generator of PMSG to provide power to the power grid [4]. Block diagram of the proposed WES based on PMSG generator with a grid-connected system is shown in Figure 1. In the generation of renewable power using wind system, which comprises interconnection apparatus, electrical power generated generator, wind turbine and controller system [15]. To improve the DC link voltage of the wind system connected rectifier. The high voltage gain is achieved by using the PWM switching signals for the converter. The terminal sliding mode (TSM) control is used for GSC control to reduce grid disturbances. Here the proposed controller controls the errors of current infinite time to achieve zero [11]. The Clarke and park transformations are used to achieve the reference voltages and currents. The PI controller used to regulate the dc-link voltage in the outer voltage loop and generate inner loop current references in the grid side converter.

3. **ZETA converter**

In this system, the ZETA converter is proposed as shown in Figure. 2 to control the DC link voltage regulation, and the output response of the converter is fed to the GSC, which provides a power grid. The ZETA topology converter produces a strong performance and generates output voltage from above or below an input voltage. Among the first stages in a PWM control unit's layout is determining how often power ripple induction is allowed, namely, for IL (PP). If EMI improves excessively, then the PWM execution can be unreliable. A thumb rule is to allocate a k value from an input current estimate of 0.2 to 0.4.

The proposed converter comprises two capacitors as well as inductors. High voltage gain is achieved through the power switch duty cycle and dc-link capacitor operation. The converter's operation is when the power switch is conducting, the D is turned to the off state, then in this charging...
Wind Generator

Rectifier

ZETA Converter

Three phases VSI

PWM Generator

Terminal Sliding Mode controller (TSM)

Grid

Figure 1 proposed WES based ZETA converter with TSM control.

Figure 2 circuit of ZETA converter

4. Control method

In this system, the terminal sliding mode control is used to WES based power generation interfaced power grid. This TSM controls the grid side converter's power switches, which controls the disturbing voltages in the power grid. Figure 2 circuit of ZETA converter. The active and reactive powers between the exchanges of grid and converter are controlled using the terminal sliding mode controller [7]. The grid side converter is controlled and provides better response during disturbances that occur externally and the variations in the internal parameters. Here the proposed controller controls the errors of current infinite time to achieve zero. The Clarke and park transformations are used to achieve the reference voltages and currents. The three-phase voltages are transformed into two variables direct and quadrature form, and also the three-phase currents are transformed using park transformation. Finally, the switching signals for the inverter are supplied through the space vector pulse width modulation technique. Figure 3 represents Controller of the TSM.
Simulations and Results

In this paper, the WES with the grid-connected system is proposed using ZETA converter to improve the DC link voltage of the wind farm's rectified voltage. The wind energy system generates power using the three-phase generator of PMSG to provide power to the power grid. Simulink model of proposed WES based on PMSG generator with a grid-connected system is shown in Figure 1. In the generation of renewable power using wind system, which comprises interconnection apparatus, electrical power generated generator, wind turbine and controller system. The terminal sliding mode (TSM) control is used for GSC control to reduce grid disturbances. Figure 4 represents Simulink model of wind farm connected with the grid system of Model predictive.

control the wind farm generates a voltage in the form of AC to power grid system, as shown in fig. 5 and fed to the rectifier to convert DC voltage. Figure 6 shows the improved DC link voltage of the ZETA converter. Figure 5represents power generated of WES. And Figure 6 represents DC link voltage of ZETA converter.
The power grid connected with WES is achieving balanced voltages without disturbances as shown in figure 7, and the current of the power grid is represented in figure 8. The power grid voltage and current are balanced, and the improvement is established by using the predictive model controller. The balanced grid voltage is 600 V, and the current is 60 A has obtained.
6. Conclusion
In this paper, the wind energy system (WES) is interfaced with the grid system using permanent magnet synchronous generator (PMSG) with robust control of integral type sliding mode controller (SMC) is proposed. The proposed controller provides switching signals for the grid interfaced inverter system which controls the grid's performance interfaced WES. DC link voltage of the wind system is improved using the ZETA converter. The high voltage gain is achieved by using the PWM switching signals for the converter. TSM control method is used to control the GSC, and in turn, the balanced grid power is accomplished. The proposed system results are verified, and the TSM control is achieved based on VSI, which is connected in the grid side validated using MATLAB/Simulink.
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