DIRECT-DRIVE WIND POWER GENERATOR SYSTEM BASED INTERLEAVED BOOST CONVERTER

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ABSTRACT
Direct-drive wind power generator has been receiving increasing attention due to their inherent efficiency. This paper outlined a procedure of adapting a small, standard, readily available PM synchronous machine for direct coupling to a small wind turbine. This was achieved through a two-cell interleaved Boost converter (IBC), which is composed of several identical Boost converters connected in parallel. The converters are controlled by interleaved switching signals, which have the same switching frequency and the same phase shift. By virtue of paralleling the converters, the input current can be shared among the cells or phases, so that high reliability and efficiency in power electronic systems can be obtained. In addition, it is possible to improve the system characteristics such as maintenance, repair, fault tolerance, and low heat dissipation. Moreover, the overall performance of the compromised design was shown to be quite good. All this was verified by simulation and experiment.

1. INTRODUCTION
Direct-drive variable speed constant frequency (VSCF) wind power generator system is a ideal topology. It can enable the wind turbine to run in a very wide speed range and it also leaves out the gearbox, which is used to make the rotational speed higher. The result is that the efficiency and the reliability are improved. At the same time, the maintenance cost and the direct cost are also reduced[1-3]. In general, PM synchronous machine (PMSM) is adopted in direct-drive wind power generator system. The three phase electricity from the PMSM is then rectified by a diode rectifier. After that a three-phase converter is fixed to transform the voltage from DC to AC and then the converter can be connected to the grid. Because the output voltage of PMSM is low when the wind speed is not high enough and the energy can’t be sent to the grid, a boost circuit is need to heighten the DC voltage, especially at low wind speed. By this the wind power generator can run in a very wide speed range. In addition, the boost circuit can correct the current waveform on the input port of the rectifier(output port of the generator), then the total harmonics distortion (THD) is reduced and the power factor is improved. The boost circuit is widely used for its continuous current, easy topology and high efficiency. As the power level of the converters goes up, it is required that the converters be shunt-wound. When the input current is high, interleaved parallel connection technology is adopted. In that case, the current in each switch is only a part of the total current. And also, by using interleaved parallel connection technology, the boost circuit can reduce the ripple and switch cost. The efficiency is improved as a result.
The ripple and EMI can be reduced by adopting interleaved parallel connection technology. But how to averaging the current becomes the main problem[4]. When two boost circuits which are controlled respectively works together, the one that has higher duty cycle will gain more current. Besides, the parameters of each element, the parasitic parameters and the changes of the parameters in different circumstances can also make the current in each circuit not equal. This paper presents a interleaved boost circuit to solve the problem. Interleaved control means the frequency of driving signals in each unit are the same but staggered a fixed angel. As to two boost circuits run together, in the first control period one circuit is controlled and in the second control period the other circuit is controlled. The fact of the interleaved control is that give every boost circuit a control in two cycles[5]. Then the amplification is improved, the duty cycle is corrected and the ripple is reduced. At the same time, the digital control is adopted in the system, which can level off the output and improve the performance of the circuit.

2. SYSTEM SCHEMATIC

The direct-driven wind power generator system schematic is shown in Fig. 1. The wind turbine and the PMSM are connected directly. And there is a diode rectifier after the output port of the generator. After the rectifier is a interleaved boost circuit. The output of the interleaved boost circuit then can be connected to the converter, after which the power can be sent to the grid. The reason for the needs of boost circuit is that the voltage generated by the PMSM at low wind speed is not high enough, which will make the feeding from the generator to the grid impossible. Boosting the output voltage of the diode rectifier can enable the wind power generator work in a wide speed range. By the way, the boost circuit can also correct the waveform on the input port of the rectifier (the output port of the generator) reduce the total harmonics distortion (THD) and improve the power factor. The circuit will have a good future.

The reliability is high for the reduction of the components in this topology, which will reduce the cost of maintenance. By using the PMSM and the VSCF technology, the efficiency of the wind power generation system is improved. And the noises are also decreased, because of the reduction of gearing elements, which will also decease the mechanism cost, heighten the efficient and shorten the manufacture period vastly. In additions, the VSCF technology applied in the system also makes the reactive power compensation possible.

The boost circuit is widely used as the simplest topology for boosting voltage. However, because of the resistor in the inductance and the switches when on, the amplification will decrease when the duty cycle is too large. At the same time, the ripple will be also large, which makes it important to enlarge the capacity of the filter capacitor, in order to keep the quick response ability. As a result, the power density is reduced and so is the efficiency. The interleaved topology can meet the two needs above together. The interleaved boost circuit topology schematic is shown in Fig. 2, and the switch state and the main waveform are shown in Fig. 3.

![Fig. 1: Direct-drive wind power generator system schematic.](image1)

![Fig. 2: IBC circuit topology schematic.](image2)

![Fig. 3: Switch state and main waveform.](image3)