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Low Power Energy Conversion With Two Phase Permanent Magnet Machine And Rectifier With Reduced Number Of Controlled Switches

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ABSTRACT

Two power generation systems that utilize a rectifier with small number of controlled switches as-sociated to a two-phase permanent magnet synchronous machine. The proposed topologies have as a main purpose converting wind energy into electrical energy for low power applications, giving them large potential to be employed in urban and rural areas. Each configuration is commanded by only two controlled switches and has natural protection against short circuit on the dc link. Compared with two three-phase generation systems that use a reduced number of controlled switches, the proposed topologies permit obtaining sinusoidal machine currents, with low harmonic distortion, using a smaller number of controlled switches. At last, to investigate the proposed system and control strategy, simulation and experimental results are presented.

INTRODUCTION

The increase in energy demand has not only expanded the role of renewable energy sources, but also requires more energy efficient systems. The use of a small wind energy conversion system (WECS) is perfectly inserted in this context, since it can reduce the energy instantaneous demand in residences, buildings, and small businesses, and thus making them more efficient. In this sense, the three-phase diode rectifier, the three-phase diode rectifier with a boost dc–dc converter, and the three-phase pulse-width modulation (PWM) rectifier have been largely employed in the WECS as a converter on the machine side. However, the use of the two first rectifiers presents the disadvantage of having highly distorted input currents, causing several undesirable effects to the generator, whereas using the three-phase PWM rectifier considerably increases the system cost, as it has a great number of controlled switches.

On the other hand, rectifiers with a reduced number of controlled switches fit as an interesting option for small WECS applications, since they may have reduced cost and low current harmonic distortion. Among these topologies, the three-phase Semi-controlled rectifier composed only of three diodes and three insulated-gate bipolar transistors (IGBTs) stand out. However, a

hysteresis current control is utilized, making the topology suitable to operate in variable switching frequency. In addition, this configuration generates a sinusoidal current only in the positive half-cycle, intensifying the low-order current harmonics. Such structure consists of a four-switch converter and a three phase machine whose one of the phases is connected to the midpoint of the dc link. Nonetheless, despite having low harmonic distortion, this solution brings high switching losses due to the high-voltage dc link.

Recently, Vienna rectifier has been employed to reduce the number of controlled switches in WECS. This converter is composed of three bidirectional switches that connect the phases of a three-phase machine directly to the midpoint of the dc link and has several advantages compared to a conventional three-phase six-switch rectifier, such as lower distortion of the input currents because of the three-level characteristic, lower blocking voltage stress, greater efficiency, and low manufacturing cost. The sinusoidal PWM and space-vector PWM are two basic control methods for the Vienna rectifier. In addition to the switching states of both methods, the current direction is required to achieve the control of the Vienna rectifier.

In order to reduce the number of switches controlled, a WECS using a two-phase permanent magnet (PM) synchronous machine. The presented topology can significantly improve the wind power extraction capability, especially with the generation system operating under low and medium wind speeds. However, it has the disadvantage of presenting a high current harmonic distortion. In two topologies, which use a rectifier with only four diodes and four IGBTs and a two-phase machine with open-end windings, were proposed. Different from, these topologies have had *dq* machine currents with low harmonic distortion, besides having presented reduced losses in the power semiconductors.

Compared to the three-phase, two-phase generation systems use a machine with restricted commercialization, needing to order their manufacture in most cases, and with greater phase current amplitude for the same phase voltage and power. However, two-phase PM synchronous machines have become increasingly interesting for low-power applications due to their relatively low-drive system cost and competitive performance when compared to three-phase PM synchronous machines.

It was noticed that two- and three-phase PM synchronous machines with the

same combinations of poles/slots can generate a similar efficiency and torque density. It was demonstrated that the two-phase system using two H-bridge processes 13% more output power compared to the three-phase six-switch converter under the same dc-link voltage.

Thus, since both machines perform similarly, the development of new topologies for two-phase systems remains an attractive and important topic. This paper investigates two small and low-cost WECSs that can be employed in urban areas, using a two-phase PM generator. The proposed topologies are composed of a rectifier with reduced number of controlled switches and a single-phase grid, focusing on the machine side. Configuration 1 is composed of two diode legs and two bidirectional switches. Each leg of the rectifier is connected to one phase of the machine, whereas neutral is connected to the midpoint 0 of the dc link, and the bidirectional switches connect the machine phases directly to the point 0.

EXISTING SYSTEM

The increase in energy demand has not only expanded therole of renewable energy sources, but also requires more energy efficient systems. The use of a small wind energy conversion system (WECS) is perfectly inserted in this contextit can reduce the energy instantaneous demand in residences, buildings, and small businesses, and thus making them more efficient.

In this sense, the three-phase diode recti-fier, the threephase diode rectifier with a boost dc–dc converter, and the three-phase pulse-width modulation (PWM) rectifier have been largely employed in the WECS as a converter on the machine sid.

PROPOSED SYSTEM

The proposed topologies have as a main purpose converting wind energy into electrical energy for low-power applications, giving them large potential to be employed in urban and rural areas. Each configuration is commanded by only two controlled switches and has natural protection against short circuit on the dc link.

Compared with two three-phase generation systems that use a reduced number of controlled switches, the proposed topologies permit obtaining sinusoidal machine currents, with low harmonic distortion, using a smaller number of controlled switches.

CONCLUSION

The proposed converters, besides having natural protection against short circuit on the dc link, employed only two

controlled switches, which allowed the reduction of the cost, weight, and volume of the system, making them very attractive options for use in urban areas. In this paper, two small wind generation systems that utilize a two-phase machine were discussed. The proposed converters, besides having natural protection against short circuit on the dc link, employed only two controlled switches, which allowed the reduction of the cost, weight, and volume of the system, making them very attractive options for use in urban areas. In addition, the proposed configurations presented better efficiency in terms of THD compared to conventionals 1, 2, and 3. Regarding the losses in the semiconductors, configuration 1 presented better performance compared to all conventional topologies, whereas configuration 2 presented the best efficiency in relation to conventional 1 and 2

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