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Design and Implementation of Unique Power Conditioning System for Wind Generator Applications

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ABSTRACT

This paper provides a unique power conditioning system (PCU) for variable rate mini wind generator applications. It has a basic generator side rectifier, galvanic seclusion with an easy dc-dc converter, and a single-phase full-bridge inverter at the grid side. Variable rate mini wind turbines based on an irreversible magnet concurrent generator (PMSG) are progressively made use of in property and also tiny business structures, in spite of their relatively low result voltage. Therefore, they can be made use of conveniently for battery charging, while their grid combination needs a PCU with galvanic isolation. Most of offered PCUs provide no galvanic isolation, or make use of fairly complicated geographies or four stage power conversions for that purpose. The dc-dc converter recommended enables reducing the complexity of the PCU. Steady state evaluation shows that the converter is capable of regulating voltage in a large range appropriate for micro wind generators, which is supported by experimental outcomes within the input voltage series of 40 V to 400 V. The model built for integration of a 1.3 kW PMSG based mini wind turbine shows excellent efficiency over the entire 1:5 variety of the offered wind generator output voltage. A research of effectiveness as well as power losses was conducted according to the wind generator power account.

Keywords:*PMSG, Wind power generation, high accuracy, low ripples, RES.*

1. INTRODUCTION

Small-scale wind energy conversion systems have become a rising trend due to increased demand for green and secure electricity supply, especially in remote areas. As a result, more than one million units have been installed worldwide. Nowadays, more than 250 producers are marketing small wind turbines (WTs) that are usually limited to 100 kW power according to different national and international regulations. Small WTs with rated power up to 40 kW dominate market; however, the average power of a small WT installed is about 1 kW. There are special feed-in tariffs introduced by many countries for small WTs that make micro WTs with rated power up to 3 kW an attractive solution for residential buildings and small communities in those countries. Despite their relatively high price, the multiple low speed permanent magnet synchronous generators (PMSGs) are a dominant technology used in variable-speed microWTs due to small volume, high reliability and efficiency, self-excitation, and brushless design.

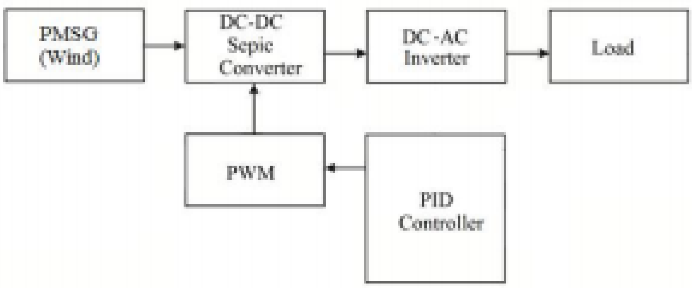

Fig. 1: Basic model

2. PREVIOUS STUDY

Solar energy and wind energy are the two renewable energy sources most common in use. Wind energy has become the least expensive renewable energy technology in existence. Photovoltaic cells

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convert the energy from sunlight into DC electricity. PVs offer added advantages over offer renewable energy sources in that they give off no noise and practically require no maintenance. Hybridizing solar and wind power sources provide a realistic form of power generation. When a source is unavailable or insufficient in meeting the load demands, the other energy source can compensate for the difference. Several hybrid wind/PV power systems with Maximum Power Point Tracking (MPPT) control have been proposed earlier. They used a separate DC/DC buck and buck-boost converter connected in fusion in the rectifier stage to perform the MPPT control for each of the renewable energy power sources. This system requires passive input filters to remove the high frequency current harmonics injected into wind turbine generations. The harmonic content in the generation current decreases its lifespan and increases the power loss due to heating. The most common solutions are: a diode bridge rectifier, its combination with a boost dc–dc converter, a switched mode rectifier that utilizes phase inductance of a PMSG, a semi bridge rectifier, a traditional two-level active rectifier composed of fully controlled semiconductors, and other more sophisticated active rectifiers. Advantages of active rectifier fed by PMSG WTs were widely advertised, especially at high wind speeds, while the combination of a diode bridge rectifier and a dc–dc converter seems to be a simple and attractive alternative with good tradeoffs between the cost and the performance, since the PMSG does not require additional excitation. A diode bridge rectifier is followed by the full bridge voltage source dc–dc converter that feeds two levels Full-bridge grid-side inverter. Active rectifiers supply phase-modulated high-frequency isolated dual lcl dc–ac converter that shapes current, which is injected into the grid through unfolded. An active rectifier operates in tandem with a qzs full-bridge dc–dc converter to supply the grid-side inverter with stable voltage. In, a micro inverter converts energy in the following four-stage sequence: diode rectifier, no isolated boost Converter, isolated fly back converter that shapes sinusoidal current and an unfolded that injects current into the grid.

3. PROPOSED SYSTEM

A novel power conditioning unit (PCU) for variable-speed micro wind turbine applications is proposed. It contains a simple generator-side rectifier, galvanic isolation with a simple dc–dc converter, and a single-phase full-bridge inverter at the grid side. Variable speed micro wind turbines based on a permanent magnet Synchronous generator (PMSG) are increasingly used in residential and small commercial buildings, despite their relatively low output voltage.The galvanically isolated single-switch qZS converter proposed belongs to the class of coupled-inductor-based impedance-source converters, where the coupled inductor at the input side combines functions of energy storage and energy transfer from the input to the output side Therefore, they can be used easily for battery charging, while their grid integration requires a PCU with galvanic isolation. Most of available PCUs provide no galvanic isolationor use relatively complicated topologies or four stage energy conversion for that purpose. The dc–dc converter proposed allows reducing the complexity of the PCU.The amount of energy captured from a WECS depends not only on the wind at the site but depends on the control strategy used for the WECS and also depends on the conversion efficiency.

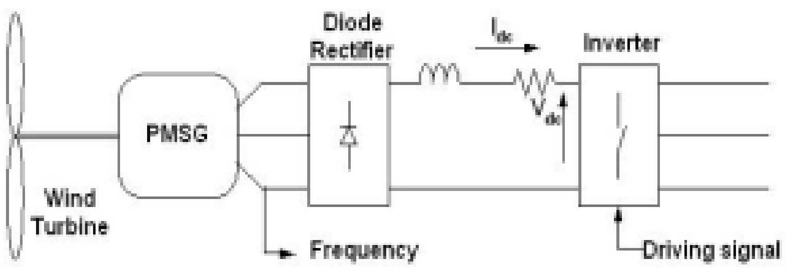

Fig.2: Proposed model.

Permanent magnet synchronous generators (PMSG) wind energy converters system (WECS) with variable speed operation is being used more frequently in low power wind turbine applications.

Variable speed systems have several advantages such as the reduction of mechanical stress and an increase in energy capture. In order to achieve optimum wind energy extraction at low power fixed pitch WECS, the wind turbine generator (WTG) is operating in variable-speed variable-frequency mode. The rotor speed is allowed to vary with the wind speed, by maintaining the tip speed ratio to the value that maximizes aerodynamic efficiency. The PMSG load line should be matched very closely to the maximum power line of the WTG. MPPT control is very important for the practical WECS systems to maintain efficient power generating conditions irrespective of the deviation in the wind speed conditions.

4. SIMULATION RESULTS

A software simulation model developed in using PSIM software, which allows easy performance evaluations is used to estimate the behaviour of these three different schemes associated with the PMSG WECS. Simulation results showed the possibility of achieving maximum power tracking, output voltage regulation and harmonic mitigation simultaneously.The PMSG phase current corresponds to the nature of the three-phase diode bridge rectifier, while the PMSG voltage is distorted due to high phase inductance. Using efficiency measurement results and measurements of voltage and current, the semiconductor power losses in the dc-dc converter can be estimated.

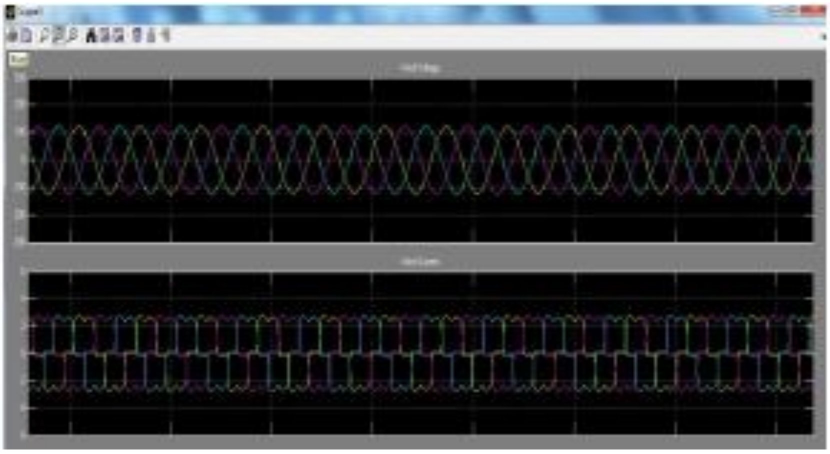

Fig.4: Output waveforms.

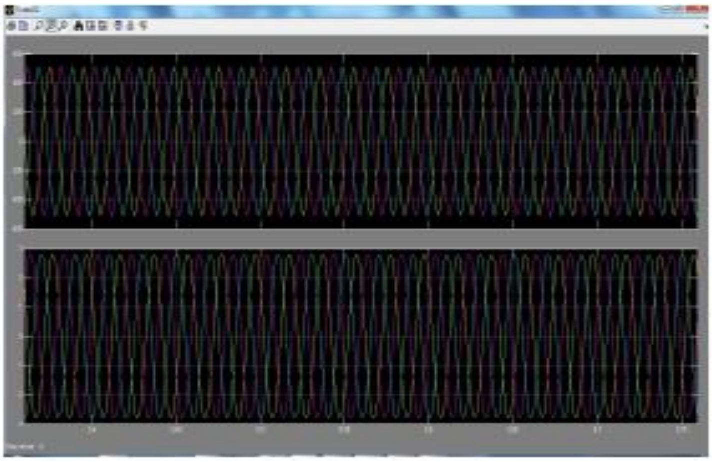

Fig. 5: Load currents and voltages.

5. CONCLUSION

This work proposed a novel galvanic ally isolated power conditioning unit intended for variable speed micro wind turbines based on the permanent magnet synchronous generator. This unit enables grid integration of sub-kW residential wind turbines into the distribution grid. Usually, reports on small

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scale wind energy conversion systems are dedicated to the enhanced control methods. However, performance of a power electronics converter used is often overlooked, in particular, proper analysis of the efficiency and losses according to the operating profile of a corresponding wind turbine. The proposed approach does not require any significant changes of the conventional control systems. Therefore, this paper pays special attention to energy conversion performance by means of the efficiency and power losses.

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