ABSTRACT

Due to increasing demand on electrical energy and environmental concerns, a considerable amount of effort is being made to generate electricity from renewable energy sources. The major advantages of using renewable sources is their abundance and lack of harmful emissions, even though wind and solar renewable energy sources are more popular, wind is the one of the most abundant renewable sources of energy in nature.

The wind energy can be harnessed by a wind energy conversion system, consisting of wind turbine, and electrical generator and power electronic interface circuits. Based on the types of components employed the WECS can be classified into fixed speed and variable speed WECS. The fixed speed requires gearbox to match turbine and generator for speed. The conversion efficiency reduces and the aero dynamic losses increases. Also, it needs frequent maintenance.

The variable speed WECS have advantages like less maintenance, more conversion efficiency, reliability and capable of operating at maximum power tracking region for different wind velocities. Many numbers of electrical generators are available for WECS such as induction generator, doubly fed induction generator, electrically excited synchronous generator, permanent magnet synchronous generator and switched reluctance generator.

The conventional squirrel cage induction generator, and doubly fed induction generator, are ill suited for variable speed WECS, as DDWECS requires large number of poles and hence it is difficult to design and install. The efficiency and power factor of these generators are lower at low wind speeds.
The electrically excited synchronous generator requires excitation and bulkier construction for low speed operations. So PMG is very attractive for variable speed WECS. There are many type of topologies are available to make PMG such as radial flux PMG, axial flux PMG and transverse flux PMG. Out of which the radial flux PMG has advantages like simple construction, higher efficiency and more reliable.

In this research work a 1 kW, 415V, 16pole, 200rpm inner rotor radial flux PMG is designed and fabricated to validate DDWECs concept, a low speed electrical motor is connected as a prime mover. To regulate the generated voltage and frequency conventionally three stage power conversion technology is used.

In three stage power conversion system, efficiency, power quality and reliability are low. To improve the power conversion efficiency, this research work proposes the matrix convertor based single stage power conversion system. The conventional matrix converter needs 36 switches for buck-boost operation, also the voltage conversion ratio is not higher than 0.866 which limits its application in WECS. To overcome the barrio in conventional matrix converter this research work proposes Z-source matrix converter (ZMC) for direct drive WECS (DDWECS). To enhance the performance of ZMC a carrier PWM scheme and modified spare vector PWM schemes are implemented.

To predict the input current THD and output voltage THD the FFT analysis is made for different input and output conditions of ZSIMC. To reduce the harmonics level a suitable PWM scheme can be implemented. The performance of carrier and sinusoidal PWM schemes based ZMC are compared based on shoot-through placement switching stress and power quality. Finally a suitable PWM scheme has been suggested for further investigation of ZMC.
The proposed PWM scheme is developed in spartran-6 FPGA processor. A 1kW, 415V, ZMC is designed, fabricated and tested for various input and output conditions. The results of ZMC is compared with conventional 3 stage power conversion systems based on number of switches, voltage boost, switching stress, power quality, losses and power conversion efficiency.