INTERNATIONAL RESEARCH JOURNAL IN ADVANCED ENGINEERING AND TECHNOLOGY (IRJAET) E - ISSN: 2454-4752 P - ISSN : 2454-4744
VOL 2 ISSUE 6 (2016) PAGES 1500 - 1504
RECEIVED : 05/12/2016. PUBLISHED: 27/12/2016
December 27, 2016

CONTROL STRATEGY OF PMSG BASED VARIABLE SPEED WIND ENERGY CONVERSION SYSTEM USING PARTICLE SWARM OPTIMIZATION

[1]Aturu Kondaiah, [2]Sri.Velappagari Sekhar,
[1]PG Scholar, Dept of EEE, Kuppam Engineering College, Kuppam,
[2]Assistant Professor in Department of Electrical and Electronics Engineering, Kuppam Engineering College, Kuppam.

Abstract:
In recent days, people migrated towards renewable energy sources to meet their power demand. Among all these renewable energy sources wind energy system is widely preferred because of its pollution free in nature, provides all time energy source and also occupies less space at ground level as compared to solar panels. Reliability and efficiency are two major factors in wind energy conversion system. A high gain Resonant Switched Capacitor (RSC) converter operates at high frequency will eliminate the switching losses and also reduces the size of the passive elements. PSO based MPPT controller can improve the accuracy of which the maximum power transmitted for the time varying wind speed. This method will reduce the time required for convergence and adaptive step size variation is achieved as compared to conventional Hill Climb Search based MPPT controller. The developed power will be applied to AC micro grid with the help of voltage source inverter. Micro grid is a local network supplied with the generated power from wind energy conversion system which eliminates long distance transmission losses and heat losses caused by the transmission lines. The simulation and analysis of the proposed system is carried out in MATLAB Simulink to obtain the system performance which validates its design and working.
Keywords: Wind energy system, Particle Swarm Optimization (PSO), Maximum Power Point Tracking (MPPT), Resonant Switched Capacitor Converter (RSC), Micro grid.

1. INTRODUCTION

Wind is an attractive renewable energy source which has gained momentum recently. However the generated energy from wind is always fluctuating in nature which may leads to power quality issues and disturbances in loads connected with grid. Recent researches focused on use of Permanent Magnet Synchronous Generator as a wind generator because of its low cost, high efficiency and self-starting ability. According to the topology concerned simple DC to DC boost converter is used in between diode rectifier and inverter. This topology will give efficiency of about 80% only. So that multilevel DC to DC converter is emerged which can give the efficiency of about 93% but it may lead to large size of components and high switching stress. The High gain Resonant Switched Capacitor (RSC) with multiple stages formed with series and cascade combination will result in efficiency of about 98%. Various Maximum Power Point Tracking (MPPT) techniques for wind energy conversion system were evolved like Tip Speed Ratio (TSR), Power Signal Feedback (PSF) and Hill Climb Search (HCS) techniques to track the maximum power from the wind. But Particle Swarm Optimization (PSO) based MPPT technique will be more efficient than other techniques. The application of PSO in MPPT will have the advantage of reduced convergence time. This technique results in adaptive step size, so that the oscillation around peak point can be avoided. The generated power will have high efficiency than other methods which can be delivered to localized loads by the help of Micro grid station near the wind generation system. Micro grid is a small scale local network of energy distribution, it will have several loads connect to it. The Micro grid has the major advantage of improved efficiency because transmission losses get reduced.

The main objective is to design, simulate and implement Particle swarm optimization technique based MPPT algorithm for wind energy conversion system with high gain resonant converter for micro grid applications. To compare the performance obtained by PSO based MPPT controlled wind energy system with conventional MPPT controlled wind energy system.

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SYSTEM OVERVIEW

This system supplies to a micro grid and contains wind turbine, Permanent Magnet Synchronous Generator (PMSG), rectifier, high gain Resonant Switched Capacitor (RSC) converter, Particle Swarm Optimization (PSO) based Maximum Power Point Tracking (MPPT) controller and an inverter. Among various electric generators,

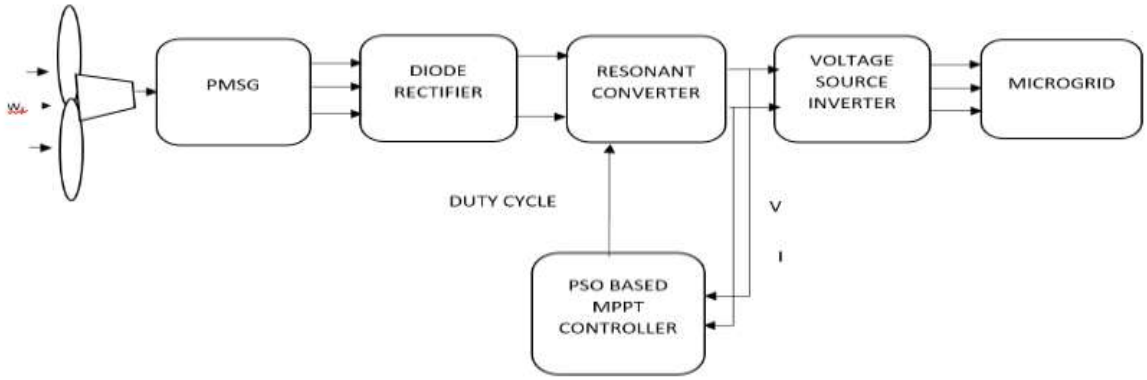

Fig.1. Block diagram of proposed system

PMSG is preferred due to its high efficiency, reliability, power density, gearless construction, light weight and self excitation features. This paper uses simplified model of the PMSG. The source EMF (ew) is proportional to the generator speed (ωm) and the equivalent resistance has a value of twice the per phase resistance of the generator. This paper proposes a multistage resonant converter which offers higher voltage gain. Here the proposed converter is modelled based ZCS (Zero Current Switching) quasi resonant converter principle also known as Resonant Switched Capacitor (RSC) converter. Here three stage resonant converter is proposed.

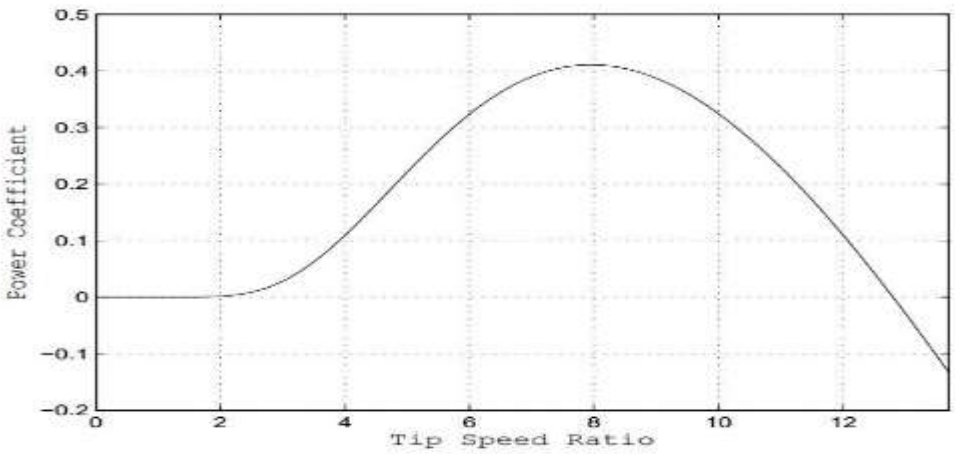

Fig.2. CVs λ characteristics

The RSC converter is composed of six resonant capacitors (Crt1, Crt2, Crt3, Crb1, Crb2 and Crb3), two output filter capacitors (Cto and Cbo), six resonant inductors (Lrt1, Lrt2, Lrt3, Lrb1, Lrb2 and

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Lrb3), two output resonant inductors (Lto and Lbo), eight diodes (Dt1, Dt2, Dt3, Dto, Db1, Db2, Db3 and Dbo), and six switches (St1, St2, St3, Sb1, Sb2 and Sb3).

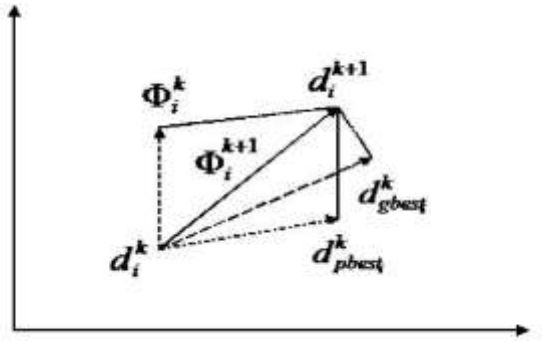

Fig.3. Modification of a searching point by PSO

In this paper, subscripts "t" and "b" represent the corresponding variables to the circuit components at the top and bottom cells, respectively. The switches (St1, St2, St3) and (Sb1, Sb2, Sb3) are controlled complementarily with a 50% duty cycle to minimize the conduction losses in the power devices and passive components. Particle swarm optimization is a computational method that optimizes a problem by iteratively improves a candidate solution with regard to a given measure of quality. It starts with a group of random potential solutions, which are called particles. These particles fly around in a multidimensional search space searching for the optimum solution by adjusting their positions depending on their own experience as well as the experience of the other particles. To be realized as a MPPT algorithm, the particle position in PSO represents the duty-cycle, the velocity is the step-size of the duty-cycle and the objective function is maximizing the converter power.

2. RESULT ANALYSIS

Voltage source inverter is used here for converting DC voltage from RSC converter to three phase AC voltage. For supplying the grid the design of inverter circuit is necessary, here the single phase or three phase inverter is required based on the load requirement at the micro grid. A new concept in power generation is a micro grid. A micro grid involves connecting several small alternative power sources in addition to the main grid on a particular site. Some examples where it could be used would be an office block, industrial site or shopping centre. Little is known about micro grid behaviour on the whole. Some models exist which describe the components of a micro grid, although to date a successful model of an entire micro grid system has not been developed. Efficiency of conventional grid is very low as compared to Micro grid because large amount of energy in the form of heat is wasted in conventional grid. Three load to be implemented for micro grid are Battery, PMDC motor, Heater. The proposed RSC converter was implemented on a 2kW PMSG to verify the theoretical developments presented previously. The proposed converter was designed to boost a 100V input to the maximum output voltage of 1500 V. The switching frequency is about 2.8 kHz. Table I lists the specifications of the capacitors and inductors.

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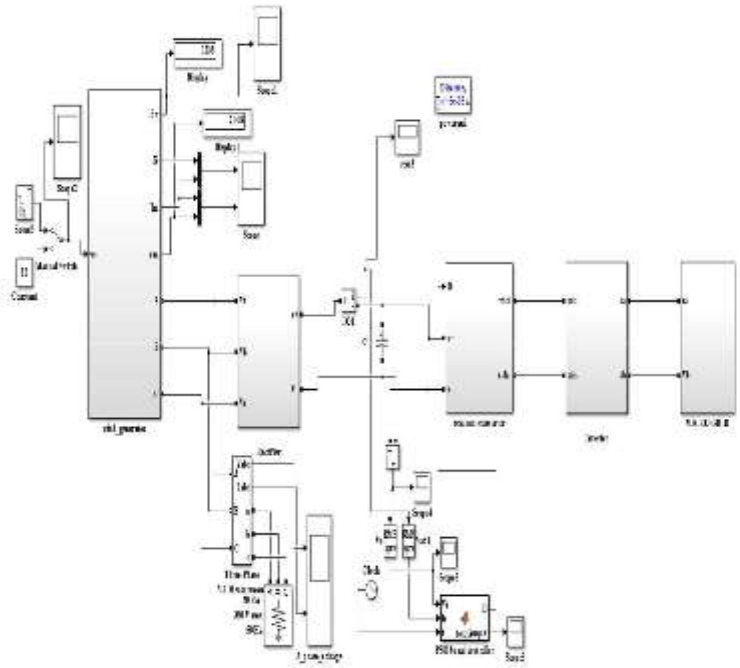

Fig.4. Overall Proposed simulation circuit

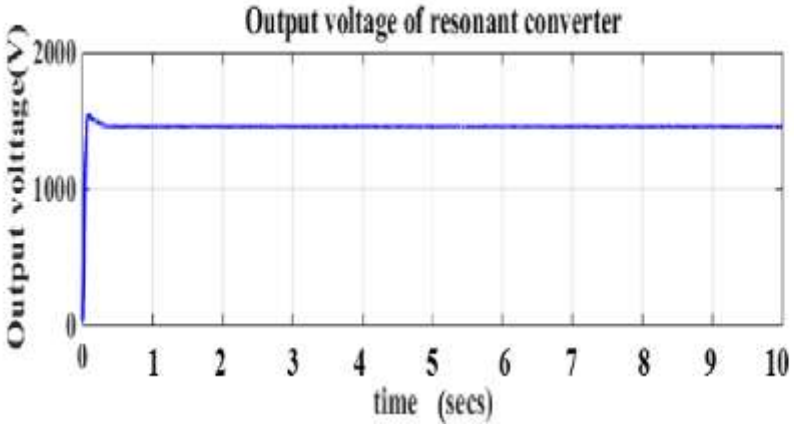

Fig.5. Output of resonant converter for 100V input

Future work may include implementation of Genetic algorithm based MPPT controller and comparison is made with PSO based MPPT controller. Increasing the number of stage of resonant converter will give very high DC voltage which can be used for HVDC transmission systems. The smart grid topology can be implemented with obtained output power to obtain better control.

CONCLUSION

Various WECS were modelled to meet the power demand whereas PMSG based WECS is widely preferred for variable speed wind turbine to achieve better efficiency. The high gain resonant converter is modelled in such a way that it will provide efficiency of about 98% at steady state as compared to other converters. The adaptive step change achieved by PSO based MPPT technique will

result in less steady state oscillation in output waveform as compared to other methods. Accuracy and reliability is achieved by this overall system.

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