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Comparison of TSR and PSO based MPPT Algorithm for Wind Energy Conversion System

K. Maheswari[1], T.Porselvi[2]

P.G Scholar, Dept. of EEE, Sri Sairam Engineering College, Chennai, India [1]

Assistant Professor, Dept. of EEE, Sri Sairam Engineering College, Chennai, India [2]

Abstract- Due to the nature of unpredicted wind speed, determining the optimal generator speed to extract the maximum available wind power at any wind speed is essential. Therefore, it is significant to include an intelligent controller that can track the maximum peak regardless of wind speed. This project describes the design and development of Tip Speed Ratio (TSR)-based maximum power point tracking (MPPT) algorithm to variable-speed fixed-pitch wind turbines. Other than the electrical power subjected to maximization, the proposed algorithm does not need any additional sensor. In addition, the MPPT algorithm does not require any prior knowledge of the wind energy system. In short, the proposed MPPT is simple, flexible, accurate and efficient in maximum wind power tracking. In this work, MATLAB/ Simulink simulation package is used to simulate the performance of the proposed MPPT algorithm.

KEYWORDS- Efficient, Intelligent controller, Maximum Power Point Tracking Tip Speed Ratio (TSR)

I. INTRODUCTION

Wind electricity generation first appearing in Denmark in 1891 and undergoing a very slow development till 1974 emerged as a serious candidate amongst the renewable after the first oil shock. The American wind power programme receiving a boost from President Carter's new energy policy led to the setting up of California wind farms with thousands of rotating wind turbine-generators producing grid quality electricity. The serious accident of 1986 at the nuclear power station at Chernobyl in Ukraine set the trend in the decline of nuclear power in almost every country through a general showing down of expansions or cancellation of new nuclear power plants. The environmental awareness also heightened and green house effect or global warming due to increased concentration of carbon-di- oxide in atmosphere attracted so much of international attention that an International Panel on Climatic Change (IPCC) was constituted under the auspices of the United Nations for a scientific study of the phenomenon and advice on the remedial measures. A policy of shift from traditional polluting technologies to clean technologies was adopted by the international governments and solar energy was advocated by the energy experts as the desired change. Wind energy in general and wind electricity in particular received finally the due attention for a sustained growth and the status of an acknowledged source for inclusion in national energy planning. The cost of wind electricity has also declined expectedly due to advancement of technology. The maximum extractable power from a renewable energy source depends not only on the strength of the source but also on the operating point of the energy conversion system. Therefore the Maximum Power Point Tracking (MPPT) is of the paramount importance in renewable energy conversion systems for not only to maximize the system's efficiency but also to minimize the return period of the installation cost. In wind energy conversion system (WECS) the concept of MPPT is to optimize the generator speed relative to the wind velocity intercepted by the wind turbine such that the power is maximized. Every year numerous research efforts are attempted to achieve better and faster techniques on MPPT in WECS. One of the commercially employed lookup table MPPT is the TSR control which additionally requires an anemometer for the wind speed measurement and also pre-known value of the optimal tip speed ratio to convert the wind velocity measurement into its corresponding reference for optimal generator speed. The TSR control technique can provide the fastest control action as it directly measures the wind speed and sets the control reference instantaneously; hence it is expected to yield more energy. However the accurate

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wind measurement is not a trivial task especially in case of large size wind turbines. As anemometer provides limited measurements of wind speed only at the hub height and cannot cover for the whole span of large blades. Moreover, due to the interaction between the rotor and the wind, this usual placement of anemometers on nacelles leads to inaccurate wind speed measurements in both upwind and downwind turbines. In other words the wind speed measured by the anemometer may not be the one intercepted by the wind turbine. Plus the additional requirement of a wind speed sensor makes TSR control more costly than PSF.

A. Introduction of Wind Energy Conversion Systems

The main components of a wind turbine system are illustrated in Fig. 1, including a turbine rotor, a gearbox, a generator, a power electronic system, and a transformer for grid connection. Wind turbines capture the power from wind by means of turbine blades and convert it to mechanical power. It is important to be able to control and limit the converted mechanical power during higher wind speeds. The power limitation may be done either by stall control, active stall, or pitch control. The common way to convert the low-speed, high-torque mechanical power to electrical power is using a gearbox and a generator with standard speed. The gearbox adapts the low speed of the turbine rotor to the high speed of the generator, though the gearbox may not be necessary for multi pole generator systems. The generator converts the mechanical power into electrical power, which being fed into a grid possibly through power electronic converters, and a transformer with circuit breakers and electricity meters. The two most common types of electrical machines used in wind turbines are induction generators and synchronous generators.

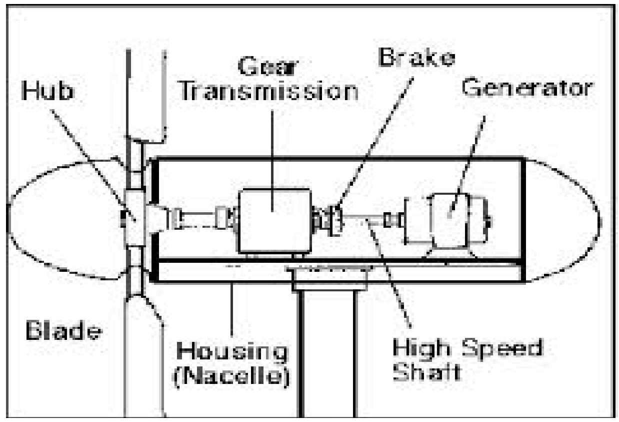

Fig.1 wind turbine system

Synchronous generators are excited by an externally applied or by permanent magnets (PMs). There is considerable interest in the application of the multiple-pole synchronous generators (either with PM excitation or with an electromagnet) driven by a wind-turbine rotor without a gearbox or with a low ratio gearbox. Synchronous machines powered by wind turbines may not be directly connected to the ac grid because of the requirement for significant damping in the drive train. The use of asynchronous generator leads to the requirement for a full rated power electronic conversion system to decouple the generator from the network. Electrical protection system of a wind turbine system protects the wind turbine as well as secures the safe operation of the network.

II.SYSTEM FLOW OF PROPOSED SYSTEM

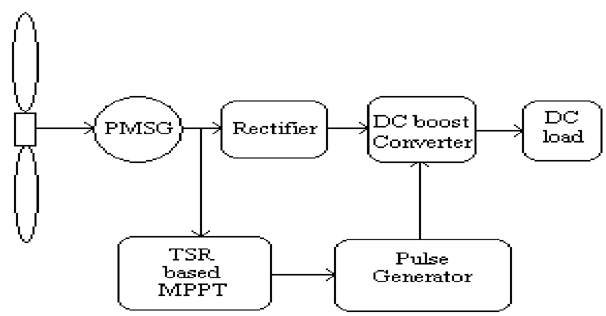

Fig.2 block diagram of proposed system

The block diagram of proposed system consists of Boost converter, rectifier, wind input, inductance, filter, pulse generator and load. First primarily wind turbine shaft

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is connected by PMSG which drives the generator by converting ac source wind power into dc power through rectifier. Always a renewable source output has lower power which ranges from 20-25 rpm to boost that power according to our load demand a dc output with high power is given to drive the load in which the load may be ac or dc based on the need of customer.

III SIMULATION RESULTS AND DISCUSSIONS

In simulation circuit wind energy is captured by wind turbines blades through mechanical shaft wind energy are converted into mechanical energy. Permanent magnet synchronous generator is used to convert mechanical energy into electrical energy which is ac supply given to uncontrolled rectifiers convert ac supply into dc supply. Forward bias diode is connected in series in order to avoid the output supply fed back to the input source. DC boost converter is used to in order to generate pulses which should have maximum ON-Time to eradicate errors in PWM conversion. In order to feed the optimal TSR value in MPPT controller, pitch angle is taken to locate the wind blades in particular direction so that maximum power is extracted regardless of wind speed. The pitch angle value should be converted into radians .Basically three parameters are needed for the input of matlab function here the parameters used are pitch angle (in terms of radians), TSR value and constant gain. In matlab m-file coding is executed and TSR value is generated which is a input to MPPT controller TSR value, wind voltage and current are given as input parameter. The output of MPPT controller generates pulse width value which is continuously varies by varying the duty cycle of PWM. If output pulse ranges between 0 and 2 the pulses varying between this frequency. To make the obtained signal in to pulses a repeater sequence is used which is nothing but clipper or clamper circuit to generate pulses .Thus the dc boost converter generate pulses which is filtered by LC filter in order to produce ripple free output voltage and current.

In this proposed method, output is extracted from wind in the ratio of 1:6 so that in this simulation for applied wind voltage the output voltage generated from the boost converter is 6 times higher than that of input voltage.

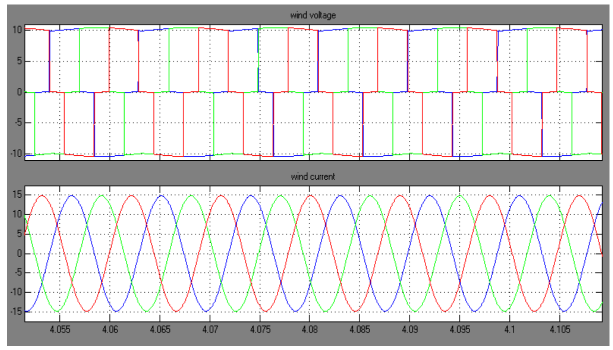
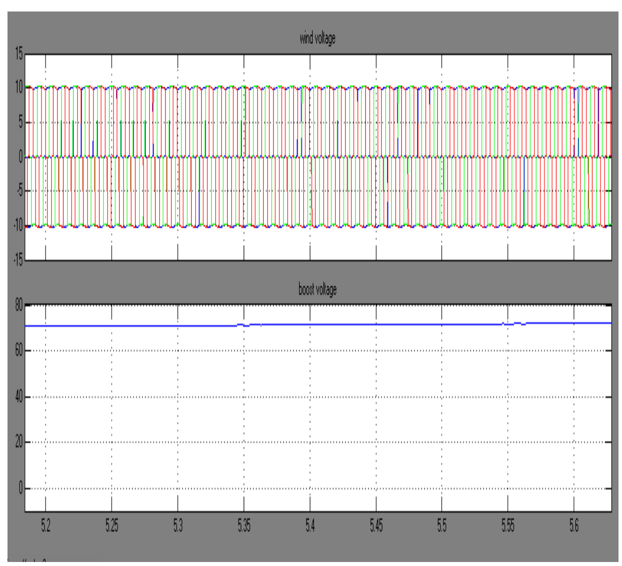


Fig.3 The voltage and current waveforms of wind

In the above result, wind voltage simulation is obtained and drawn between wind voltage and time period and wind current graph is obtained in three phase input as it ranges between -15 to+15.three phases representing here is R,Y and B .In fig.2 for wind voltage the boost voltage is generated in tha range 60v which is six times greater than input voltage of wind.In fig.3 boost output pulse is obtained in the range between the values 0 and2. Based on the ON switching time of the boost converter the maximum storage output can be generated.



Time offset->

Fig. 4 wind generator voltage vs boost voltage

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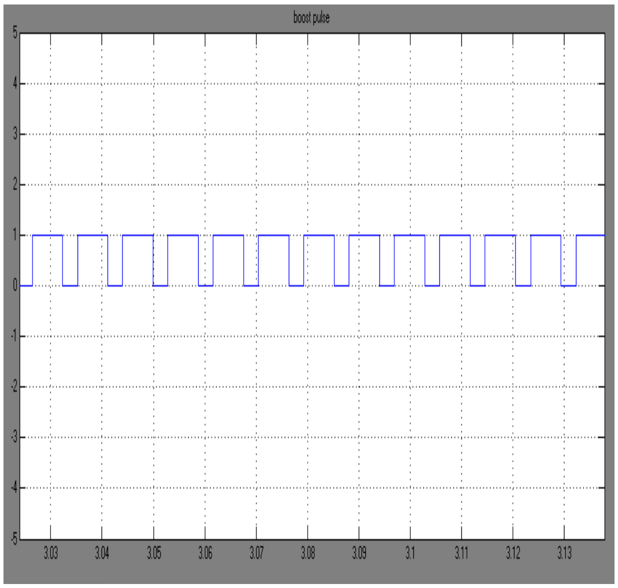

Fig .5 simulation diagram of boost pulse

IV CONCLUSION

Including a MPPT algorithm in a wind energy system is necessary due to the instantaneous and unpredictable change of the wind speed. In this project, Tip speed ratio (TSR)-based MPPT algorithm is successfully applied to control the duty-cycle of the boost converter that interfaces the wind turbine to the load, in a way that guarantees extracting the maximum available power from the wind. As it neither requires a prior knowledge of the energy system nor mechanical sensors, the proposed algorithm is simple, independent, and flexible.

V FUTURE ENHANCEMENT

Therefore in near future I would like to extend my project by developing Parameter free PSO based MPPT algorithm and Bacterial foraging optimization based MPPT algorithm by changing the parameters in search space or parameter free based PSO. By comparing the above two methods performance analysis can be evaluated.

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