WIND POWER CONTROLLER FOR STANDALONE SYSTEM USING SWITCHING DEVICE

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Abstract

By using the wind energy, electrical energy can be generated in minimum cost. Also it is eco friendly type of energy. The wind speed varies with respect to time and accordingly the power generation also varies. The power that is generated may exceed the demand limit or it can be less than the demand limit. This paper explains the slope assisted maximum power point tracking algorithm(SA-MPPT) and Power Limit Search algorithm(PLS). The power controller acts when power exceeds the power limit or power is less than the limit of the power. All the simulations are done in MATLAB SIMULINK software.

Key Words : Slope assisted maximum power point tracking(SA-MPPT), Power Limit Search(PLS), Power Controller.

1. Introduction

Global warming and environmental deterioration are the main factors of conventional fossil fuels supply and consumption of the energy. The Renewable energy is replacing the Conventional energy sources. The power can be generated by using the solar energy, wind energy, geothermal energy, biomass energy, ocean energy etc. As the initial cost of renewable energy systems is very high but after the installation it can be run with the minimum cost as it is not in the case of conventional energy sources.

Thermal power plants has the highest contribution in the energy generation in India. Other conventional sources are also efficiently generating the energy. But they all have many environmental hazards. Now recently renewable energy has been emerged because they can generate the same power as the conventional energy sources can. The renewable energy systems has various power conversion system . These power conversion systems are used to match the frequency with the grid. Power electronics also plays very important role in wind energy conversion system. The wind energy conversion system can be of two types. The electrification of any remote areas and which is not connected to the grid is called as standalone system. The another system is the grid connected system. In wind energy conversion system the wind energy is converted into the electrical energy by using generator which can be of various types such as permanent magnet synchronous generator, induction induction generator etc. Generally permanent magnet synchronous generator is used nowadays because of its various advantages like less cost, less

size, high efficiency, less maintenance, high energy generation capability etc.

To obtain maximum power many maximum power point tracking algorithm are used. The MPPT techniques is classified as, tip speed ratio(TSR) control, the optimum relation based control(ORB), the perturb and observe(P&O) control[1]-[5]. In TSR control. In ORB control maximum power point is obtained when their is maximum relationship between the different system variables. The rotating speed continuously changes and the MPP is tracked for the specific wind speed in Perturb and Observe Algorithm. In this algorithm the voltage varied by taking the constant step size. Generally power speed relation of wind turbine has been used for P&O control. But nowadays authors use dc link voltage and duty cycle for P&O control. By applying this the cost of the system and reliability of the system reduces. Also the wind speed measurement is not required and hence again the cost reduces more. Pre information of the parameters of the system is not needed hence this method is not so complicated and can be considered as reliable. This method has disadvantage that when the wind speed changes drastically the power does not change with change in wind speed. [6]-[7].

This paper explains the Algorithms used to manage the power. Speed of turbine and measured power is related to tip speed ratio by using the slope relationship. At only one TSR of each wind speed, maximum power is obtained. . The generator speed values and the power is represented by using the slope relationships. The atmosphere changes continuously. Hence before this algorithm stores its previous state on the Maximum Power Curve by the relationships. When the wind speed changes, the algorithm determine optimal tip speed ratio that allows it to search the exact location of MPP. The PLS algorithm is used to reduce the demand of dummy load. As the heat dissipation in the dummy load is the main very big issue

of Standalone wind energy system. Hence to reduce that PIS algorithm is used which will manage the excess power by adjusting the Tip Speed Ratio.

Fig.1represents the Power management Controller which consist of a wind turbine,filter,converter circuit,Boost chopper,SA-MPPT module and PLS module. The output of the wind turbine which is a mechanical energy is given to the permanent magnet synchronous generator(PMSG).This mechanical energy is converted into electrical energy by using PMSG.The three phase output of PMSG is then given to the filter circuit. The LC filter will make the output ripple free. This output is given to the three phase converter circuit.

2. Description of Scheme

Fig. 1: Block Diagram of Power Management Controller

The wind that flows is captured by using the wind turbine. This kinetic energy is then given to the generator which converts mechanical energy into electrical energy. The conversion system is used to match the frequency. The controller will control the switching of Boost Converter. For controlling SA-MPPT and PLS algorithm is employed.

3. SA-MPPT & PLS Algorithm

The SA-MPPT algorithm has the good feature of detecting the the wind speed and with respect to that the error in Maximum power point search is minimized. It stores the current slope value and with respect to that it calculates the maximum value of tip speed ratio. The system parameter may may change their behaviour due to long life or any other atmospheric change but this algorithm easily get adjusted to these situation also[1]-[4]. If there is any change in wind then the algorithm calculate the power speed change ratio (PSCR) where the step in current values is represented by subscript n. The PSCR gradually decreases upto zero and the algorithm operates in its normal way at no change in wind speed. The speed change polarity becomes positive if there is any increase in turbine speed and is found to be negative when the turbine speed decreases. Fig.2. shows the flowchart for SA-MPPT.

The difference between the SA-MPPT method and the conventional method is that the SA-MPPT method calculates the tip speed ratio values which reduces the time for maximum power point. Minimum step size is required in this algorithm. The oscillation at the MPP can be reduced by this algorithm by moving to the previous operating point at the time of change in the location of MPP whenever the power is decreased or there is no change in wind speed[8]-[10]. Continuous searching of MPP is done whenever there is change in wind speed. Tip speed ratio get calculated to mark the previous operating point. The tip speed ratio is calculated for another wind speed condition and then search for MPP starts from the previous state. The change in both power and tip speed ratio are calculated in this algorithm. This algorithm is very adaptable to drastic change in atmosphere and is also has the ability to detect the change in wind speed. At the ending point it checks for the following condition-

- $|P_{change}| \leq \epsilon_{p,MPP}$,
- $P_{change} \geq -\epsilon_{p,MPP}$
- change in polarity of wind(s_{pol}).

Fig. 2. Flowchart of Slope Assisted Maximum Power Point Tracking Algorithm

Fig.3. shows the flowchart of Power Limit Search Algorithm. PLS has the same methodology as of SA-MPPT but only the difference is it does not search for the maximum power point tracking algorithm but it searches for the output power level. The PLS maintains the value of tip speed ratio(TSR). The controller generally works in MPPT mode but if the person observed that generation of the power is greater than that of the limit of power then the activation of PLS occurs. The tip speed ratio value for the transition between the SA-MPPT and PLS.Unlike other MPPT algorithm the PLS Algorithm does not increase power with increase in wind speed. The PLS algorithm will decrease the rotor speed if the power increases that of the power limit[1].

Fig. 3 : Flowchart of Power Limit Search Algorithm

4. Simulation Results

Fig. 4 : Power Management Controller simulated in MATLAB

Fig.4. shows the system simulated in MATLAB. The limit of power is 1200W. If power is less than or equal to 1200W then Sa-MPPT works And if power is greater than 1200W then PLS get activated. This will generate the reference speed. This reference speed is then compared with the rotor speed and the output is then given to the PI controller. The PI controller converts the output into voltage. This voltage is compared with the carrier wave and gives the switching pulses which are used to switch the IGBT of the Boost Converter. The wind turbine profile is given by (1).

$$\lambda_i = \frac{1}{\lambda + 0.08\beta} - \frac{0.035}{\beta^3 + 1} \quad (1)$$

The turbine model is described by (2),

$$C_p(\lambda, \beta) = c_1 \left(\frac{c_2}{\lambda_i} - c_3\beta - c_4 \right) e^{\frac{-c_5}{\lambda_i}} + c_6\lambda \quad (2)$$

Fig. 5 : Performance of Perturb and Observe

Fig.6. shows the performance of SA-MPPT algorithm. The cut-in-speed is 3m/s . From 3m/s the power starts increasing. As the wind speed changes the power becomes constant within 2-3 sec.as shown in Fig. 5 Perturb and Observe Algorithm does not give fast response for frequent change in wind speed[1]. This is not the case in SA-MPPT algorithm.

Fig. 6 Performance of SA-MPPT

Fig. 7 : Performance of Power Management Controller

Fig. 7. shows the performance of power management controller. The limit for power is taken as 1200W. Initially the wind speed is 8m/s. The power is 1000W at 8m/s hence SA-MPPT is activated. Then the wind speed changes to 8.4m/s and that time the power is 1190W and hence again SA-MPPT is activated. When the wind speed changes to 9m/s at that time the power is more than 1200W and hence at 13sec PLS is activated. At 22sec the wind speed is 7m/s the power is 800W therefore again SA-MPPT is activated.

5. Conclusion

In this paper a Power Controller is analyzed by using Simulink MATLAB. The SA-MPPT algorithm and PLS Algorithm is used for standalone wind energy system. In P&O the power becomes steady in 8-10 sec for frequent variation in wind speed but if the same wind variation is applied to SA-MPPT algorithm then it gives steady power in 2-3sec. The PLS is activated when the generation is more than the demand. Hence this algorithm removes dump load and hence power loss is reduced. The simulation is done for the PMSG of 3kw.

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