A NOVEL WIND AND SOLAR HYBRID SYSTEM WITH OPEN WINDING PERMANENT MAGNETIC MACHINE

K.GAYATHRITEJA
PG scholar Dept of EEE
Vignan university
gayathriteja09@gmail.com

A.SRIHARIBABU
Assistant professor Dept of EEE
Vignan university
Srihari.vignan@gmail.com

ABSTRACT-A combination of different energy generation systems based on renewable energies or mixed is known as Hybrid power system .Hybrid systems capture the best features of each energy resource and can provide "grid-quality". Renewable energy sources are suitable option to supply electricity in fragmented areas or at certain distances from the grid. Due to the elimination of the mutual influence, the proposed machine has the prominent advantages of high reliability and it can be used in the novel wind and solar hybrid power system compared to the traditional wind and solar hybrid system with the advantages of system structure simplification and control modules reduction.This project describes dynamic modelling and simulation of a renewable energy based on hybrid power system. The phase windings of open-winding permanent magnet machine are separated, compared to the traditional wind and solar hybrid system one side of the open-winding permanent magnetic machine was connected to the rectifier , the other side was connected to the inverter for the regulation of the output voltage. Modelling and simulations are carried out using Matlab/Simulink to verify the effectiveness of the proposed system. The results show that the proposed hybrid power system can tolerate the rapid changes in natural conditions and suppress the effects of these fluctuations on the voltage within acceptable range.

INTRODUCTION

The solar cell depends on the weather factors, mainly the irradiation and the cell temperature. Therefore, the weather factors such as the irradiation and the temperature are utilized for the estimation of the maximum power in this paper. After many technological advances, proton exchange membrane fuel cell technology has now reached the test and demonstration phase.

The selection process for hybrid power source types at a given site can include a combination of many factors including site topography, seasonal availability of energy sources, cost of source implementation, cost of energy storage and delivery, total site energy requirements, etc. the city lights, communication base stations, the monitoring system and users in remote areas. The load of these systems is typically tens to several hundred watts. Besides, for about 80W the load characteristics are clear and the time for power supply is certain. For example, the communication base station generally requires all-day power supply, and the city lights are generally lighten at night for about 60W.

It can be considered that the load of the wind and solar hybrid power system is fixed, and the complementary wind and solar power work together to supply the load. In the traditional wind and solar hybrid power system, for energy conversation and paralleled for the power supply the wind and solar need separated power converters. By two-stage converters the system structure is complex and the wind and solar energy have to be converted, the control strategy is also complex and efficiency is low[1]. At the rated wind speed when wind and solar hybrid power system operates, wind turbine power output will normally be greater than the consumed load power, so batteries are required to charge for storing energy. Based on the open winding permanent magnet machine in order to simplify the wind and solar power system, this paper presents a novel hybrid system.

SYSTEM STRUCTURE

The wind turbine is directly connected to open-winding permanent magnet machine, as shown in Fig. 1, the system structure of the novel wind and solar hybrid power system. For the load one side of the open-winding is connected to the rectifier with the DC side, and the other side is connected to three phase inverter with the DC side connected to the solar panels and storage batteries in paralleled. The controller acquires of DC voltage signal of the load-side, to the controller the voltage and current signals and position signals of the machine are also collected

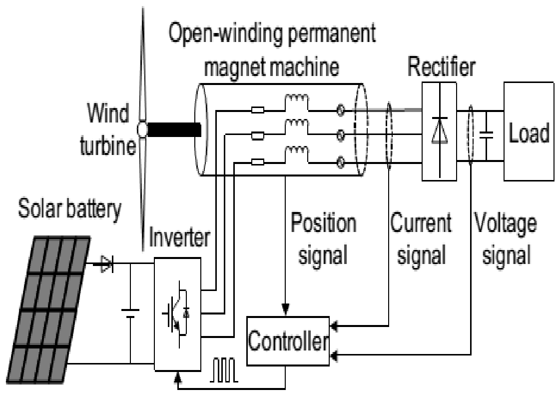


Figure 1. Structure diagram of the novel wind and solar hybrid power system

For the maximum power tracking of the wind turbine the inverter is controlled, and for the maximum power tracking of the wind turbine regulation of the output voltage of the DC load-side .

OPERATING PRINCIPLE AND CONTROL STRATEGY

A. Analysis of Operating Principle

To control the voltage of the DC load-side the inverter is used, and the phase currents of the open-winding permanent machine can also be regulated by the inverter is proposed in this paper. As the torque of the open-winding permanent magnet machine has a clear relationship with the phase current. Therefore, for the maximum power tracking of the wind turbine the appropriate control strategy of the proposed system can achieve torque control by the power signal feedback method or the perturbation and observation method.

The torque equation of open-winding permanent magnet machine is[2]:

$$T_e = \frac{3}{2} P_n \left[\varphi_f i_q + \left(L_d - L_q \right) i_d i_q \right] \qquad (1)$$

Where, Te is output torque, Pn is the number of the pole pairs, ψf is the permanent magnet flux, Ld and Lq are the d-axis and q-axis inductance, id and iq are d-axis and q-axis current of phase windings.

Ld is equal to Lq, due to the inherent characteristics of the surface-mounted permanent magnet machine. Therefore, by the output a-axis and q-axis current of the inverter the torque has a linear relationship with the q-axis current, and the voltage of DC load-side and MPPT of the wind can be controlled. In the conventional small and medium-sized wind and solar hybrid power systems, as relatively stable and operation time is assured the load can be considered. Solar and wind power work in the complementary state. The surplus power is stored in a solar battery ,when the output power of the wind turbine is greater than the load consumption, the lack of power can only be supplied by the solar battery when wind turbine output power is less than the load consumption.. As the phase inductance and resistance of the permanent magnet synchronous machine is small, the energy storage of the inductance can be ignored, the instantaneous power of the load can be expressed as:

$$P_L = \frac{3}{2} \left(U_q i_q + U_d i_d \right) + \frac{3}{2} \omega \varphi_f i_q \qquad (2)$$

Therefore, by controlling the output power PL the output voltage can be stabilized and it shows that PL can be controlled by id and iq. To control the torque of the open-winding permanent magnet machine the q-axis current iq can be to achieve the maximum wind power tracking, and to stabilize the output power PL of the DC load-side the d-axis current id is used. Ud and Uq can be controlled by d-axis current and q-axis current. In order to achieve the voltage regulation of the DC load-side and the MPPT control strategy of the wind turbine the control strategy of the d-axis and q-axis voltage of the inverter is used.

B. Analysis of Control Strategy

In the proposed control strategy of the system the coordinate transform of the vector control is used. The implementation of the control strategies requires the corresponding voltage, current and rotor position signal detection. The decoupling control of component of the excitation current and torque current of the permanent magnet machine can be achieved. The system control block diagram is shown in Fig. 2.

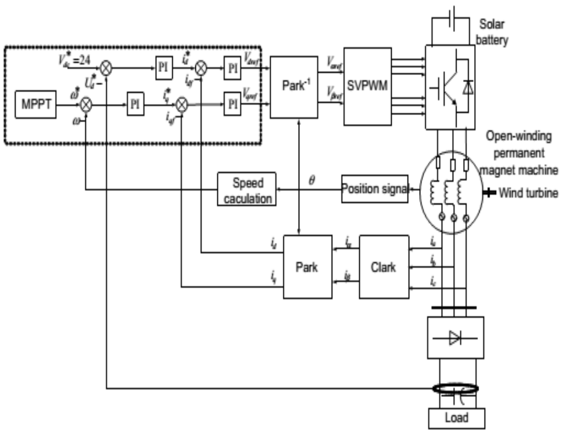


Figure 2. System control block diagram.

compared to the machine speed, MPPT generates the best wind turbine speed reference value ω*, in the control loop the deviation though the PI regulator acts as the q-axis current reference value iq*used to control the machine torque. By the d-axis current id DC load side voltage control loop is achieved. Vdc*is given voltage of the DC load-side, to control id. the deviation of the given voltage and puts voltage is calculated by the another PI regulator. To generate the switching pulse signals for the inverter the role of the SVPWM module is used.

C. MPPT Control Strategies

Under the different MPPT control strategy in order to compared the characteristics of system, to track the maximum wind power of the wind turbine the tip speed ratio and power signal feedback method are used. In the proposed system common MPPT control schemes of tip speed ratio method, the power signal feedback method and the perturbation and observation method can be used.

SIMULATION MODEL AND SIMULATION ANALYSIS

A. Simulation Model

The simulation model is composed of the battery, inverter, open winding permanent magnet motor, rectifier, load, wind turbines and the module of the control algorithms.In accordance with the aforementioned system architecture and block diagram of control algorithms, the wind and solar wind power system simulation model is built by the software Matlab/simulink [7], and shown in Fig. 3.

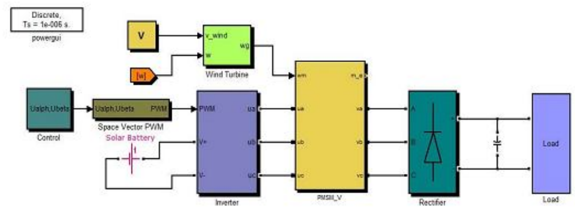


Figure 3. Simulation model of the novel wind and solar hybrid power generation systems.

B. Simulation Parameters

The system simulation parameters are shown in Table.

TABLE I. SYSTEM SIMULATION PARAMETER SETTINGS

Wind Turbine Parameters	Wind wheel radius (m)	0.8
	Maximum wind energy utilization coefficient	0.48
	Optimum tip speed ratio	0.002
	Moment of inertia(kg · m^2)	8.1
Open-winding Permanent Magnetic Machine Parameters	Pole pairs	12
	The stator resistance (Ω)	0.1
	Direct-axis inductance (mH)	0.035
	Quadrature-axis inductance (mH)	0.035
	Permanent magnet flux (Wb)	0.036
Other Parameters	Battery voltage (V)	48
	Output voltage (V)	24
	Rated load (W)	120

C. Analysis of Simulation results

To simulate and analyze the characteristics of the hybrid power system the above simulation model is used, simulation parameters are shown in Table1. Using these two MPPT control strategy, which are optimum tip speed ratio method and the power signal feedback method, the control performance under constant load and the wind speed changes are also studied. The simulation time is set as one second, and the step size is 2e-6s..

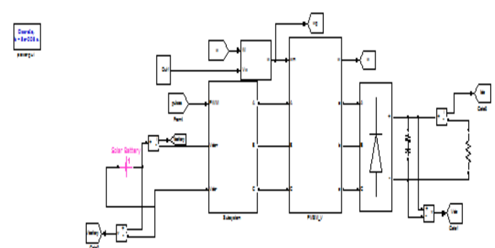


Fig 4 Block diagram of simulation pmsg1

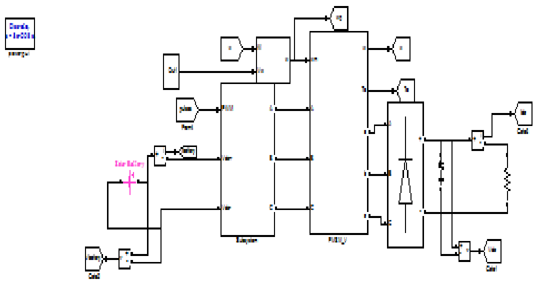


Fig 5 Block diagram of simulation pmsg 2

Fig. r shows the wind speed simulation waveform, the initial wind speed of 2.5m/s to 5m/s, while the wind speed varies to 5m/s at the 0.1, and change to be 7m/s at 0.4s, then, it varies to be 4m/s at 0.7s

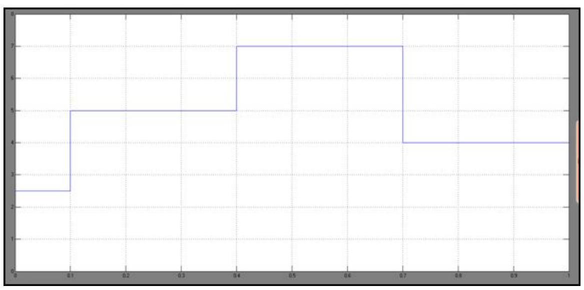


Figure 5 Wind speed simulation waveform

As the wind speed change is the extreme working conditions of wind turbines. In extreme conditions the stability and the tracking performance of the system are given by the simulation results.

1) Optimum tip speed ratio method simulation analysis

To control the speed of the wind turbine at the optimum tip speed ratio the tip speed ratio method is used by torque current of the open-winding permanent magnet machine. The wind speed, wind turbine radius and wind turbine speed can be obtained, in the close-loop control method to calculate the given speed signal for the machine they are used, then, the wind turbine runs at optimal tip speed ratio.

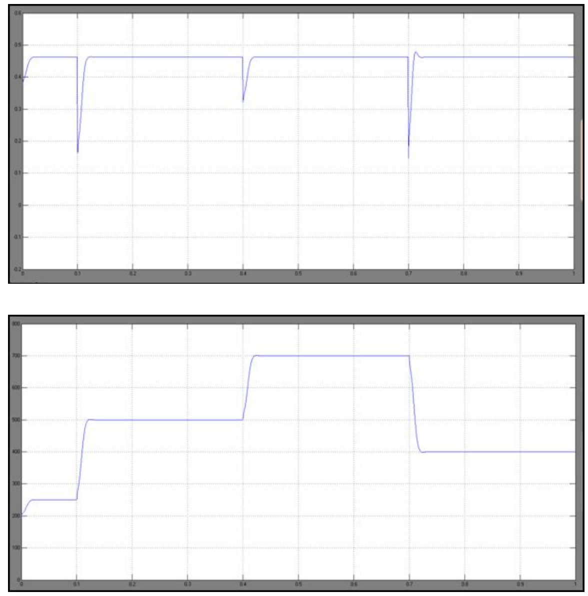


Figure 6. Simulation waveforms of wind energy utilization coefficient and wind speed

It can be seen that when the wind speed occurs a mutation, wind energy utilization coefficient Cp dump will take place. Fig. 6 shows the simulation waveforms of the wind turbines wind energy utilization coefficient and the speed of wind turbine. speed would not change suddenly due to the greater inertia of the wind turbine. In this situation, its wind energy utilization coefficient is lower the wind turbine no longer works in optimal tip speed ratio operation. As the MPPT control strategy works, according to the corresponding wind speed and wind energy utilization coefficient the speed of the wind turbine will be adjusted will gradually restore to the maximum value 0.48.

.

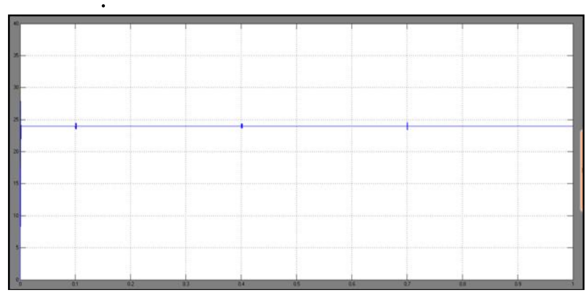


Figure 7 Simulation waveform of output voltage under the tip speed ratio method

The simulation waveform of the output voltage of wind and solar hybrid power generation system is shown in Fig 7. For supplying DC load power it can be seen that the output voltage can be well stabilized at 24V at the aforementioned condition of speed change

The simulation waveforms of the solar battery output power, the wind turbine output power and load power consumption is shown in fig 8. Combining the Fig. 5 and the Fig. 2, it can be seen that, when the wind speed increases, the output power of the wind turbine will increase, while the solar battery output power will reduce, when wind speed reduces. The output power of solar and wind effects show good complementarily, and the combination of both the output power stabilizes at 120W.Wind turbine output power will reduce, while the corresponding solar battery output power will increase.

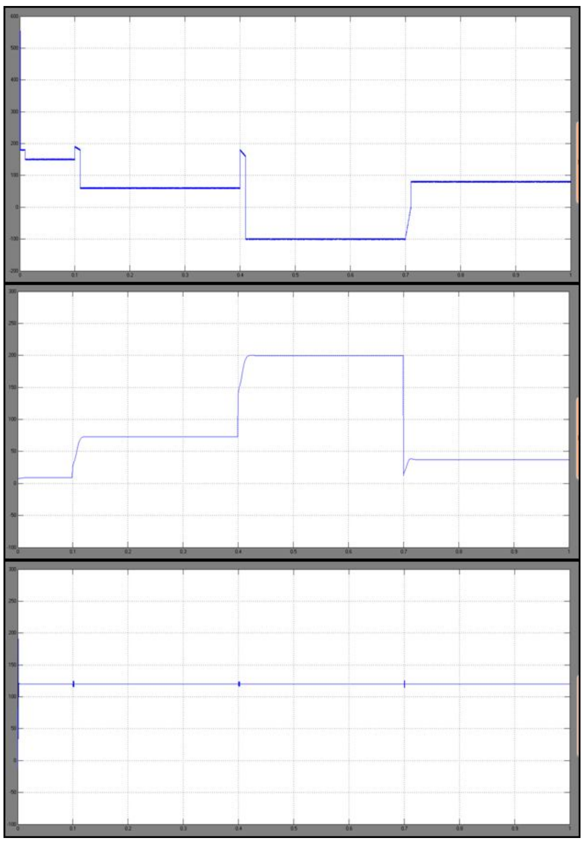


Figure 8. Simulation waveforms of solar battery power, wind turbines power and DC load-side power

2) Power signal feedback simulation analysis

At this point, wind turbines have the maximum output power, and the correspondence between speed and power is the maximum output power-speed curve. For the particular wind turbine, there is an optimum speed. At the maximum output power-speed curve power signal feedback control method of the wind turbines is to control the turbine speed strictly. This curve and the corresponding wind speed under power-speed curve have an intersection, which is the final operating point of the system.

Under the control strategy of power signal feedback Fig. 9 shows the simulation waveforms of the wind energy utilization coefficient and wind turbine speed. It can be seen that, the wind energy utilization coefficient will also dump down when the wind speed varies. However, by the closed-loop control method. it can be gradually restore to the maximum value 0.48 and the speed will gradually change to the best run-speed .

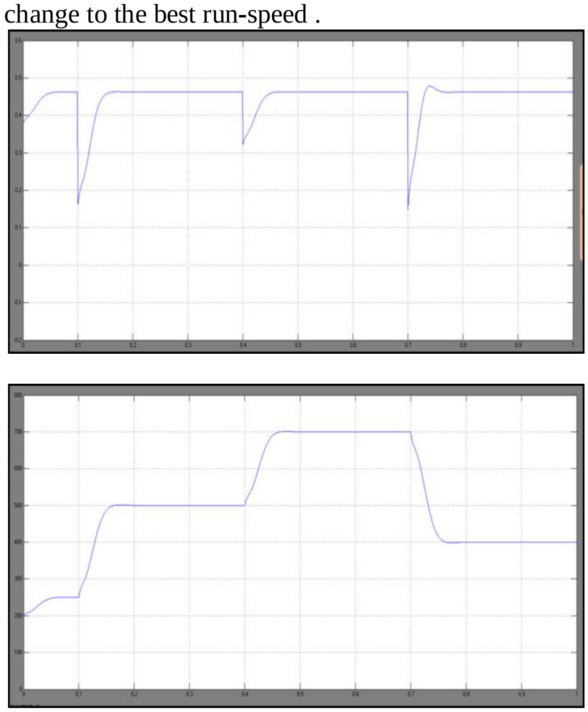


Figure 9. Simulation waveforms of wind energy utilization coefficient and wind speed.

To reach the optimum speed combining the Fig.9 with Fig. 4, the wind turbine speed changes relatively smoothly, and it requires longer time, the wind energy utilization factor restores to the maximum needs more time. On the maximum output power-speed curve, this is because the power signal feedback method makes the wind turbine operate strictly and the speed is adjusted by the power difference between the wind turbine output and the generator output. Comparing with the than the generator output power, when wind turbine output power is greater the rotating speed increases and the energy stores in the form of kinetic energy, when wind turbine power is less than the generator output power, the unit speed decreases and the kinetic energy releases to complement the generator output power.

Under the control method of the optimum tip speed ratio compared with output voltage, the voltage ripple of output voltage waveform is small, because the rotating speed changes smoothly and changes in the output power is more gentle Fig. 10 shows the simulation waveform of the output voltage under the control method of the power signal feedback. In the case of changing wind speed, to maintain the output voltage in the 24V effectively the system can always be able, so the system owns good tracking performance and fast dynamic response.

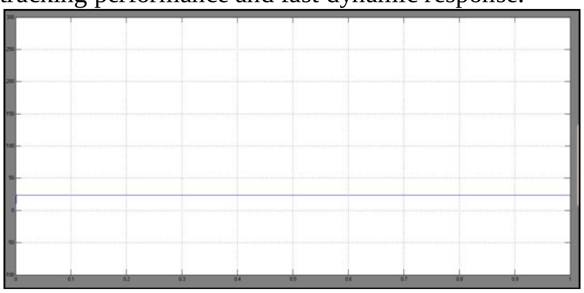
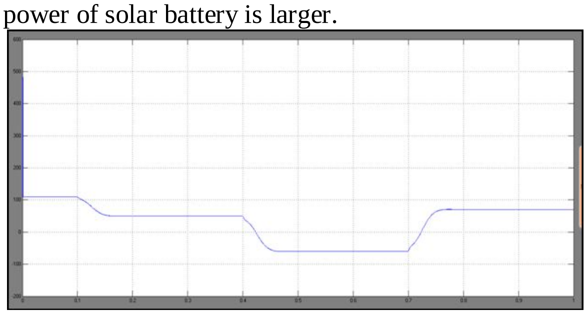


Figure 10. Simulation waveform of the output voltage under the power signal feedback method

Similar to the simulation waveforms of control method of the optimum tip speed ratio, solar and wind presents good characteristics of complement. Simulation waveforms of solar battery, wind turbines and load-side power under the power signal feedback method as shown in Fig 11. When the wind speed is larger, the wind turbine output power is greater and the solar battery output power is smaller,. In addition, compared with the optimum tip speed ratio method, the changes of the wind turbine output power is more gentle and the adjustment time is longer. when the wind speed is lower, wind turbine output power is relatively small then the output power of solar battery is larger.



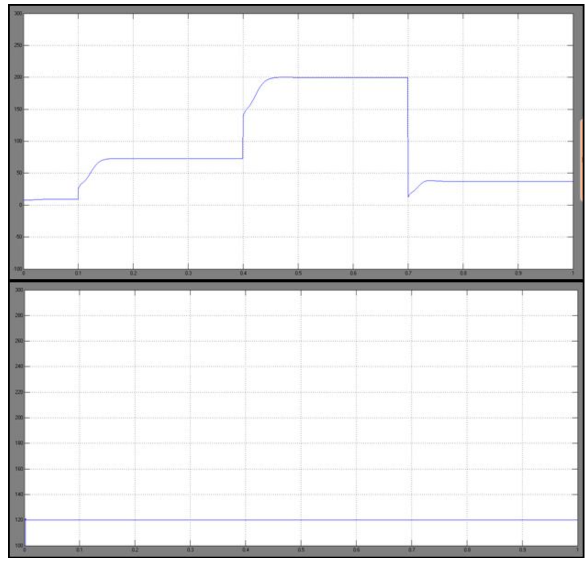


Figure 11. Simulation waveforms of solar battery power, wind turbines power and DC load-side power

In Fig. 12 the yellow curve is the maximum output power-speed reference curve of the wind turbine, under the power signal feedback method the black curve is the operation curve of the simulation system. When the speed is low, to follow the reference curve the system can be well controlled. The power changes up and down in large amount around the reference curve during the wide speed range. To the mechanical angular velocity as the power input of the open-winding permanent magnet machine will has influence, and the electromagnetic torque and the speed of the machine changes smoothly, it requires the previous PI controller to be adjustable.

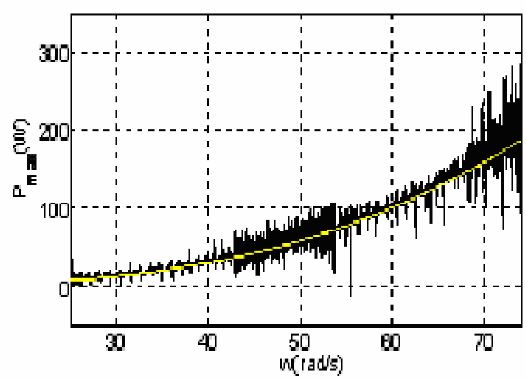


Figure 12. The simulation waveform of the actual running curve of the maximum output power

CONCLUSION

In this project, a novel renewable energy based hybrid power system is developed and modelled for a standalone user with appropriate power conventional controllers. In the above simulation results the system can achieve a good stability of the rectifier output voltage and two-way flow of energy with the condition of wind speed change and constant load. The novel wind and solar hybrid power system based on open-winding permanent magnet generator is suitable for multiple generation, and the proposed structure of the system can also be spread to other applications. The available power from the renewable energy sources is highly dependent on environmental conditions such as wind speed, radiation, and ambient temperature. To overcome this deficiency of the solar cell and wind system, an integrated system is used. The proposed system can be used for off-grid power generation in non interconnected areas or remote isolated communities. The simulation results of power signal feedback method and the tip speed ratio method are basically the same, both of them can achieve maximum wind power tracking, however, the unit speed presents a slight lag on the response of the wind speed changes.

REFERENCES

[1] Mu-Shin Kwak, Seung-Ki Sul, “Control of an Open-Winding Machine in a Grid-Connected Distributed Generation System”, IEEE Transaction on Industry Electronics, vol. 44, pp. 1259–1267, July 2008.

[2] Guo Qingding, Sun Yi-biao Wang Limei, Modern permanent magnet motor servo system. Beijing: China Electric Power Press, 2006.

[3] Ahmed G. Abo-Khalil, Dong-Choon Lee, “MPPT Control of Wind Generation Systems Based on Estimated Wind Speed Using SVR”, IEEE Transactions on Industrial Electronics, vol. 55, 2008.

[4] Le Zhang, Bo Zhou, Fangshun Cheng, Guangjie Zuo, “A Novel Maximum Power Point Tracking Control Method Suitable Doubly Salient Electro-Magnetic Wind Power Generator System”, 2009.

[5] Research on Control Strategies of Open-winding Permanent Magnetic Generator Qing tang Deng, Jiadan Wei, Bo Zhou, Chu Han, Chang Chun Chen Jiangsu Key Laboratory of New Energy Generation and Power Conversion Nanjing University of Aeronautics and Astronautics Nanjing, Jiangsu Province, China

[6] Zhang Ling, Hu Chi-Bing, Yang Rongrong, “SVPWM control of PMSM speed control system modeling and simulation”, Science Technology and Engineering, vol. 8, pp. 2435 ~ 2438, 2008.

[7] Xue D Research on Control Strategies of Open-winding Permanent Magnetic Generator Qing tang Deng, Jiadan Wei, Bo Zhou, Chu Han, Chang Chun Chen Jiangsu Key Laboratory of New Energy Generation and Power Conversion Nanjing University of Aeronautics and Astronautics Nanjing, Jiangsu Province, China