International Journal of Engineering Research-Online
A Peer Reviewed International Journal
Articles available online http://www.ijoer.in

Vol.3., Issue.4., 2015
(July-Aug)

RESEARCH ARTICLE

ISSN: 2321-7758

A WIND TURBINE WITH PERMANENT MAGNET SYNCHRONOUS GENERATOR RENEWABLE POWER GENERATION AND POWER SUPPLY

VIGNESHA.R[1], Y.DAMODHARAM[2], CH. JAYAVARDHANA RAO[3], Dr. N.VENUGOPAL [4]

[1]PG Scholar, Kuppam Engineering College, Kuppam, Andra Pradesh, India [vignesha.rk@gmail.com]

[2 & 3]Associate Professor, Kuppam Engineering College, Kuppam, Andra Pradesh, India [damu.smj@gmail.com, jk222.kec@gmail.com]

[4]Professor & Head, Kuppam Engineering College, Kuppam, Andra Pradesh, India [vgopal _m_e@yahoo.co.in]

ABSTRACT

The paper presents the wind generator system with permanent magnet synchronous generator and energy system for storage. The analysis of theoretical and characteristics of power generation is discussed. The power of wind and potential is analyzed to meet the future energy demand. Detailed structure of the wind turbine and synchronous generator focused on the interconnection and the enhancing stability of the power supply. The model of wind generator, the boost converter by employing PID controller method and the energy storage system to deliver the stabilized voltage. The power electronics circuits used as a interfacing and their model and analysis has been emphasized. The generic three phase AC-DC-AC converter, methods of converter control for wind power generation and PMSG generator modeled. PID controller method employed to deliver the single phase supply for domestic appliance. This work provides a detailed methodology to assess the impact of wind generation on the voltage stability of a power system. In order to verify the presented model and the control strategy, simulation MATLAB/Simulink software have been conducted. Simulation results proves the stable output of the supply.

Keywords— Wind Energy Conversion System (WECS), Permanent Magnet Synchronous Generator (PMSG), Energy Storage System, Wind Power


VIGNESHA.R


Y. DAMODHARAM


CH.JAYAVARDHANA RAO


Dr. N.VENUGOPAL

1. INTRODUCTION

The global warming and harmful effect of carbon emission is increased awareness among the people. Wind energy has experienced the highest growth in past and coming years. Because of its clean and renewable energy sources. Wind energy is a pollution free resource, its inexhaustible potential and also cost effective advantages over the other. The drawback of wind is irregularity in occurrence and also discussed to increase the energy generation from the wind. Recently, the development of wind generation has resulted in an increasing impact of wind power on power systems. Small unit of system is inevitably affected. In the wind energy conversion systems (WECSs), the project focused on the small units to provide the electric power supply in remote areas the are beyond to connect to electric power grid or its cannot be connected economically by adopting the opposite control method. First, a optimizing robust control with intent of increasing the power output of a speed wind turbine with permanent magnet synchronous generator. The wind power generation is a converting aerodynamic power to rotor and from rotor power to the electrical power.

The increasing of power generation is achieved by closed loop structure in which the control stage of extreme synergy. PMSG are particularly focused invariable wind energy application and not require external excitation method. The cost benefit is that rectifier may be used at the generator terminals since no excitation method is needed. The generator torque with an wind rated value and pitch controller online to stop the load of wind turbine. Controller is designed against robust variation of wind speed. The proposed control strategy is validated through simulation with proposed PID controller switching technique to reduce the power fluctuation and load current under fluctuating with rated wind speed. With variation of the wind, the switching of control can lead to significant in power voltage and variable loading. This innovative control strategies for wind operation, from the aspects of maximizing the power output and reducing the power flicked and variable load. Due to variable nature of wind, the utilization of an energy storage device such as a battery can significantly enhance the reliability the reliability of a small unit of wind system. The simulation results demonstrate the proposed scheme of the stand alone wind based energy sources for domestic application.

2. PROPOSED SYSTEM MODEL

The energy captured from the wind by the blades is modeled asymmetry in the turbine due to disturbance imposed the vortex interaction of tower and the mechanical swings in the blades are imposed in order to give the accurate value of wind energy conversion systems. The dynamic conversion system comes up from the modeling of the dynamic behavior appropriate to the main subsystem of this system. The variable Speed wind turbine drive train, the PMSG and power converters are achieved. Drive train dynamic is modeled by two mass model approach and more appropriated in detaining the behavior of the system.

The turbine rotor of wind is connected to the synchronous generator and its converts the mechanical energy into electrical energy. The generator ac voltage is converted into dc voltage through a rectifier bridge. The bridge rectifier output is matching the generator ac voltage to the dc voltage, while the boost converter produces the constant dc voltage. The output of the boost converter is connected to the battery bank. It is fed to the inverter further to the load. The voltage constant for variable wind speeds. The power supplied to the storage system when wind speed is high and further stored in the storage system. When the wind speed is low, the generator, together with the battery bank, can provide sufficient energy to the loads. Furthermore, this voltage is applied to a single- phase transformer, which boosts up the voltage to 230 V. The inverter controls the transfer of power. A dc link capacitor coupled between the generator and the electronic circuits and offers control flexibilities for the power converters. The proposed model diagram as shown in the figure 1. The developed model and control method was simulated in Matlab/Simulink and validated for different conditions. The test result shows the good performance and the developed model control.

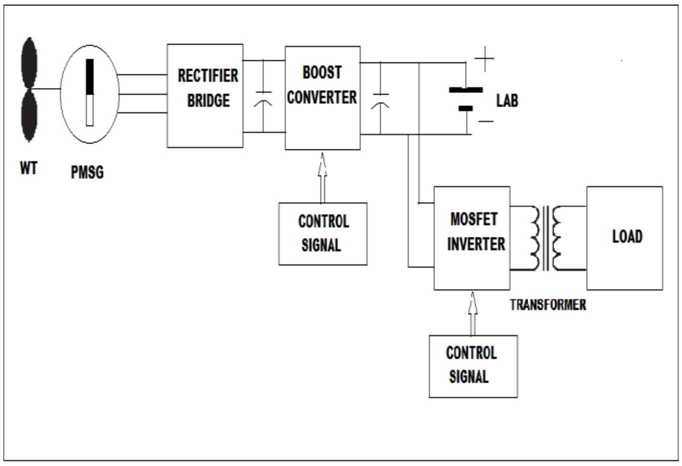

Figure 1: Proposed model diagram

2.1 Wind Turbine

Wind turbines harness the power of the wind and use it to generate electricity. Horizontal axis wind

International Journal of Engineering Research-Online
A Peer Reviewed International Journal
Articles available online http://www.ijoer.in
Vol.3., Issue.4., 2015
(July-Aug)

turbines (HAWT) are most common type of wind turbines. Its design is taken from the design of windmills, which have blades that rotate and spin around a horizontal axis. The horizontal axis mainly is the rotor shaft that is considered the electrical generator shaft. Horizontal axis wind turbine has three blades around a rotor. The rotor is connected to the generator shaft. The electrical generator shaft rotates and the generator generates electricity. The electrical power produced passes through a power conversion system. The stored energy from the wind is a low quality form of wind energy. So many factors influence the factor of the wind speed and it's modulated as source intermittent variable energy. It's characterized as variable in the magnitude of wind energy and direction.

Wind energy as random variable given by

$$u = u_0 \left[1 + \sum_n A_n \sin(\omega_n t) \right]$$

The wind energy of mechanical energy conversion passed to the rotor of a wind turbine and factors influenced between the tower of wind turbine and energy conversion.

Mechanical effects have been modeled by Eigen swings mainly due to the asymmetry in the wind turbine, tower interaction of vortex and mechanical Eigen swing in the blades. The mechanical power passed over the wind turbine rotor has been modeled.

Maximum power coefficient by considering pitch angle and equal to

$$c_{p\max}(\lambda_{opt}(0), 0) = 0.4412$$

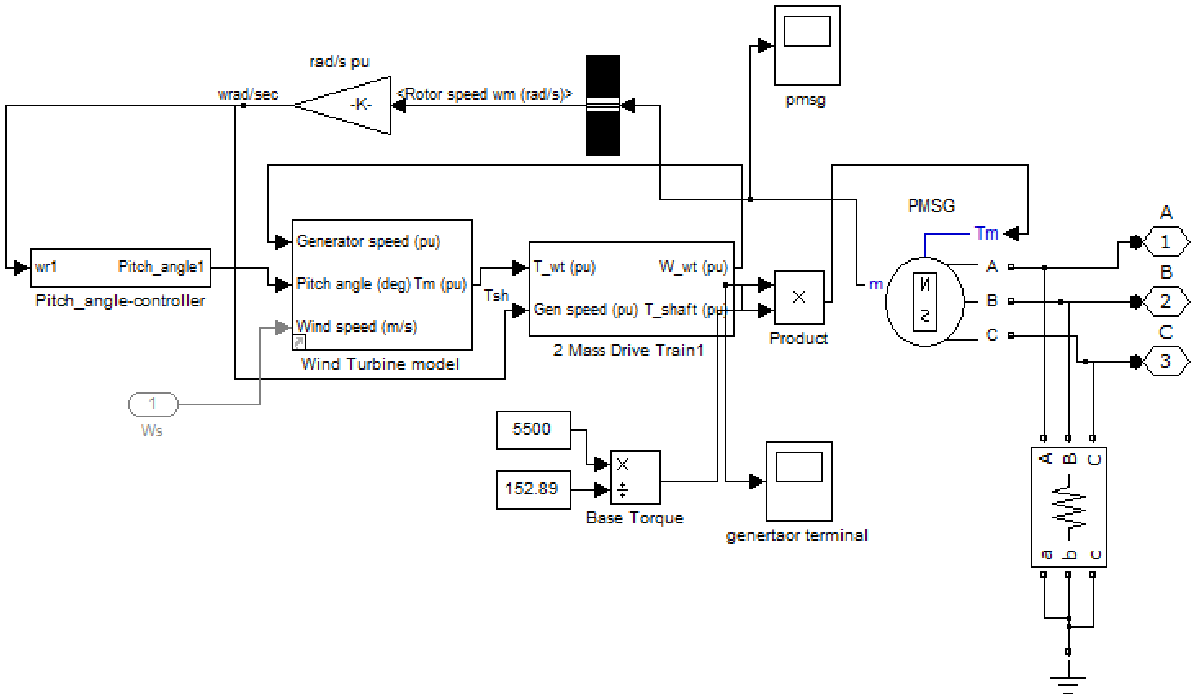

Figure 2: Simulink model of wind turbine with pmsg

The amount of power in the wind is a function of the wind density, swept area of the blades, Ab, the coefficient of performance, Cp that has to be less than 0.59 which is Betz

Limit and proportional tp cube of wind speed, *vw*, Betz limit is the upper limit of power that we can extract from the wind. The wind power equations are:

$$P_w = \frac{1}{2} \cdot \rho \cdot A_b \cdot v_w^3$$

The mechanical power, *Pm*, extracted from the wind can then be expressed as

$$P_m = \frac{1}{2} \cdot \rho \cdot A_b \cdot v_w^3 \cdot C_p(\lambda, \beta)$$

The mass of two drive model implemented in Simulink is shown in figure 4. It's a wind turbine rotor and shaft coupling system.

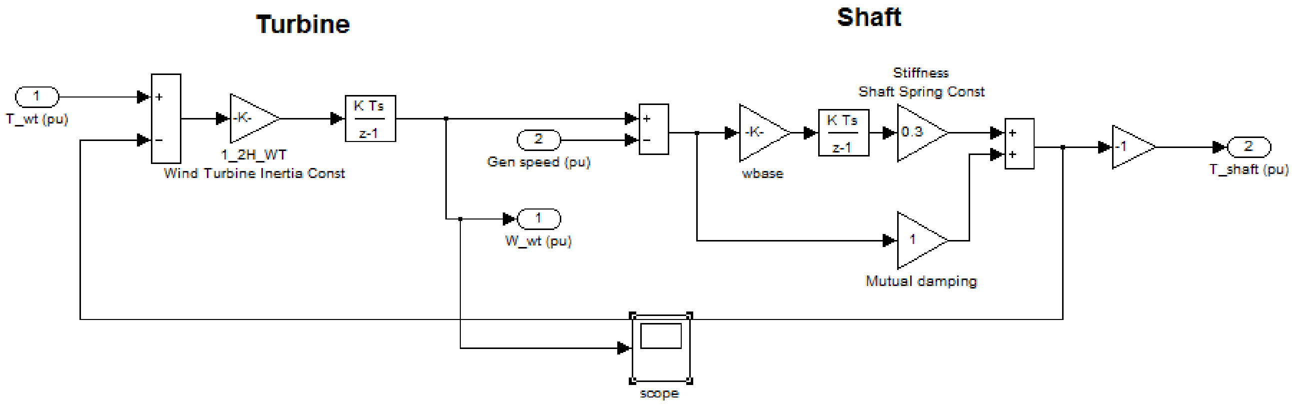

Figure 4: Wind turbine drive train based on 2 model based

The system describes shaft torque T, W_wt as output and T_wt, generator speed per unit as input. It is a closed loop system where the feed forward path is provided before the gain. The input is amplified by gain then it is multiplied transfer function. The output give W_wt as the first output result shown in figure 3.The output have generator speed as a input with a process of T_wt with further amplification with an gain. It is compared with the calculated input giving its final output T_shaft.

The equation for the two mass models is tensional and state equation for the rotor angular speed at the wind turbine.

The rotor angular speed at the generation given by.

$$\frac{d\omega_t}{dt} = \frac{1}{J_t}(T_t - T_{dt} - T_{at} - T_{ts})$$

Where Jt is the moment of inertia

Tdt wind turbine bearing resistant torque

Tat is viscosity of airflow and hub resistant torque

Tts is the torque of tensional stiffness

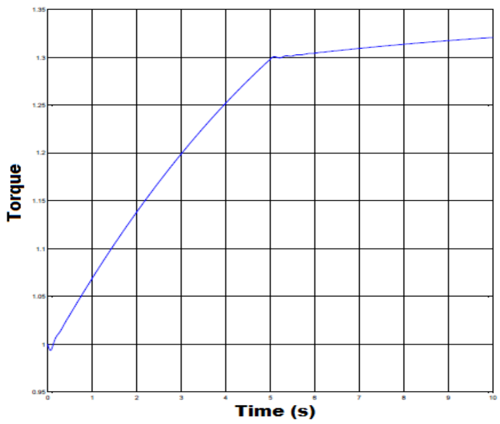

Figure 3: Output of shaft torque

2.2 Permanent Magnet Synchronous Generator

Permanent magnet synchronous generator is the major source of electrical energy. Permanent magnet synchronous generator has drawn a wind energy conversion and it is promising solution to direct drive wind energy system. Major advantages of PMSG based wind turbine gearbox removed, due to its salient pole of permanent magnet synchronous generator operating at low speeds and also the Self excitation brings about various benefits. This not only cost reduced, also the whole system become more reliable. PMSG are used commonly to convert the mechanical power output wind turbine output into electrical power. Lower maintenance requirements and thus lower cost are the main reasons why PMSGs are proposed with variable speed wind systems. It is named as synchronous generators because f, the frequency of the induced voltage in the rotor (armature conductors), is directly proportional to P, the number of Permanent magnet stator poles. A constant of proportionality is, where RPM is the revolutions per minute of the rotor (or angular speed) in a permanent magnet synchronous generator, the magnetic field of the rotor is produced by permanent magnets. The figure 5 shows the speed variation of the synchronous generator with a variable wind speed.

The dynamic model of PMSG is derived from the two-phase reference frame in which the *q*-axis is 90° ahead of the *d*-axis, with respect to the direction of rotation.

The electromagnetic torque output as shown in the figure 6.

The electromagnetic torque can be expressed as

$$Te = 1.5np \cdot [(Ld - Lq) idiq + \psi PM\, iq]$$

The permanent magnet synchronous generator output voltage and current shown in the figure 7.

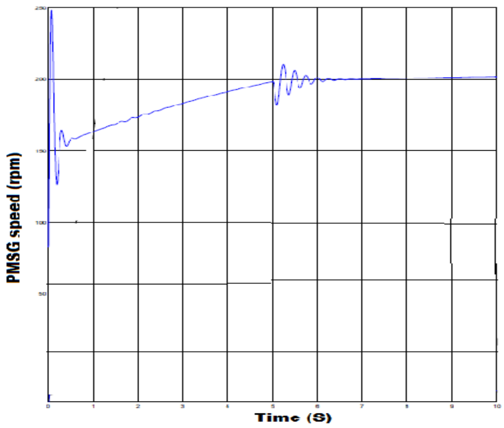

Figure 5: Permanent magnet synchronous generator speed.

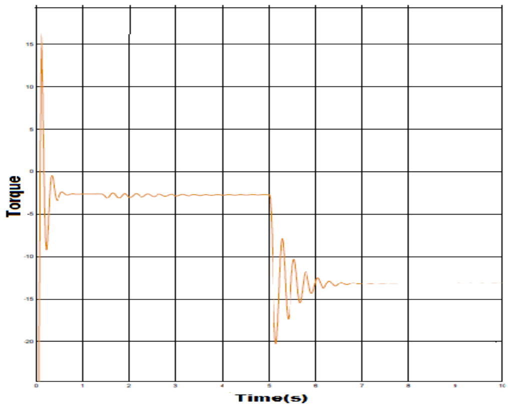

Figure 6 : Permanent magnet synchronous generator electromagnetic torque

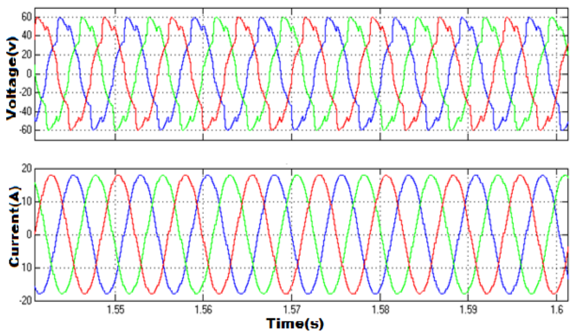

Figure 7: Permanent magnet synchronous generator output the voltage and current

2.3 Boost Converter

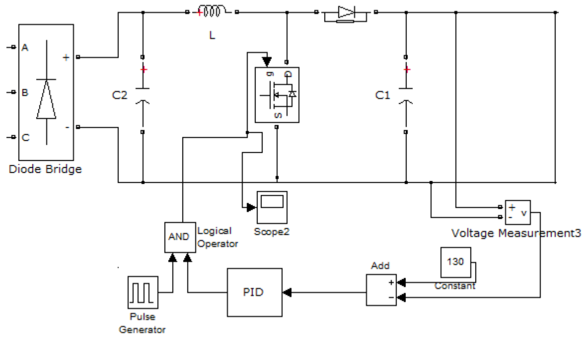

Figure 8: Boost converter simulink model

Modeled diagram of boost converter as shown in the figure 8. The rectifier is matching the generator's ac voltage to the dc voltage, while the boost converter provides the required level of constant dc voltage. The DC/DC boost converter only needs four external components: Inductor, Electronic switch, Diode and output capacitor. The principle of inductor volt second balance the states of average value and the dc component of applied voltage across the inductor winding is zero and average current that flows through the capacitor must be zero. To determine the voltages and current of dc to dc converter operated in periodic steady state and the average inductor current and voltages over one switching. The converter can therefore operate in the two different modes depending on its energy storage capacity and the relative length of the switching period. A PID controller is used to regulate the output with positive voltage reaction, which realizes and modulation factor is obtained and is used as a allusion for the pulse generator.

2.4 Storage System

An energy storage system is composes a single phase mosfet inverter and a bank of LAB 12V each connected in series to afford the expected value of the inverter with a state of battery voltage. The energy storage system uses rechargeable batteries for load demand, where the store of electric energy used for during the peak load of peak periods. The renewable energy uses such as a storing the power generated form wind based PMSG during the normal speed is used at low speed condition. Battery charges during the period of low demand and returning the energy the load. Load leveling helps expensive peaking the cost of generator over more hours of operation. Status of the battery voltage as shown in the figure 9.

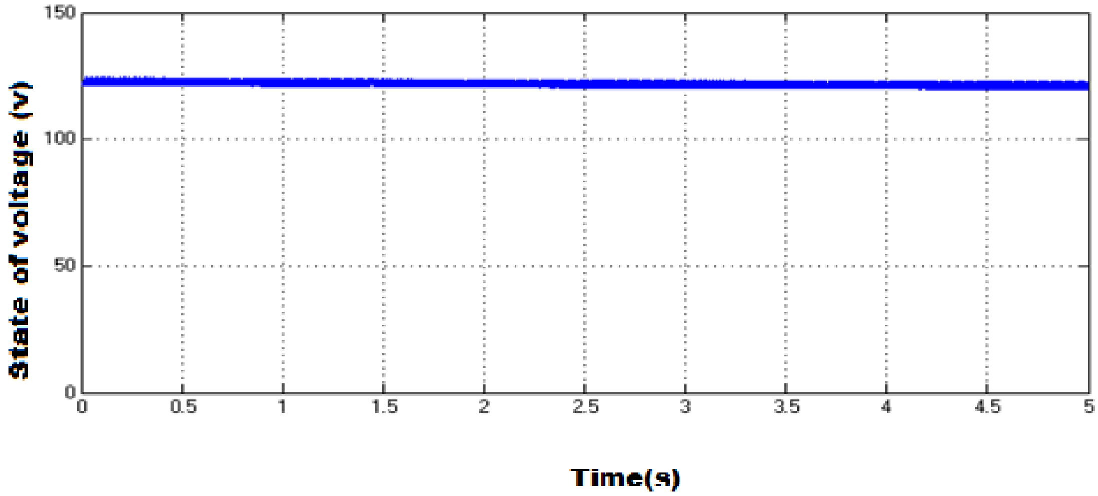

Figure 9: Status of battery voltage

2.5 Mosfet Inverter

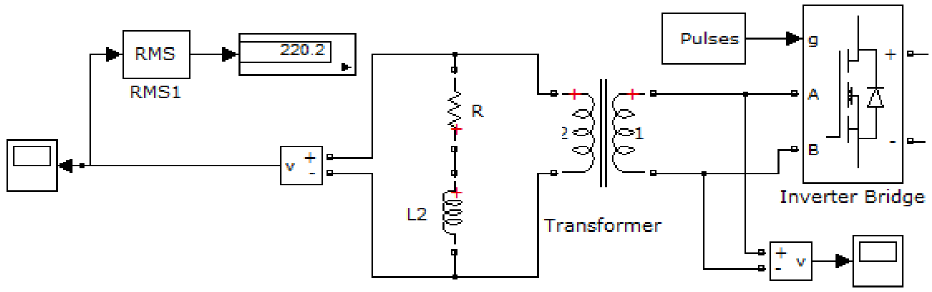

Figure 10: mosfet inverter Simulink model

The mosfet inverter Simulink model as shown in the figure 10. A mosfet inverter is an electrical power converter that changes Direct current (DC) to Alternating current (AC). The output of the inverter bridge is controlled the pulses. The sinusoidal pulse width modulation inverter is commonly used in industrial applications. The most efficient method of controlling the output voltage is pulse width modulation control within the inverter. The sinusoidal control pulses is considered and modeled. The output of the inverter is fed to the transformer to boost up. The secondary terminal of transformer is allied to the variable load. An RMS voltage waveform as shown in the figure11.

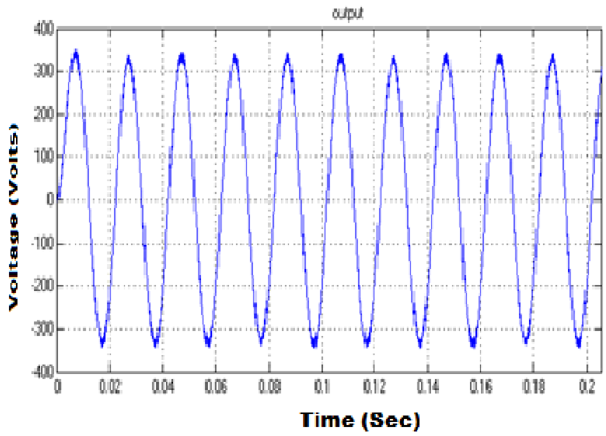

Figure 11: Output voltage waveform

3. Conclusion

This paper presents the PID control system for the distribution of electricity for standalone wind system. The assessment model of the ability to predict the drive train in favour of the two mass model for the wind energy conversion systems with electric power ranges. With information about rotor speed, load demand, battery state-of-charge and simple rules of PID, control signals were generated for a maximum power recovered from the wind in respect of load demand, and can extend battery life. The advantages of proposed PID controlled method and it needs the optimal tip speed ratio and maximum Cp, fast response time, simple controller. The simulation result shows the power deliver to the connected load. This paper shows that the maximum power is traced on implementing closed loop scheme to remove fluctuation occurred in the output by maintaining the switching in the form of pulses on application of controlled rectifier.

REFERENCES

[1]. R. A. Mastromauro, M. Liserre, and A. Dell'Aquila, "Control issues in single-stage photovoltaic systems: MPPT, current and voltage control," IEEE Trans. Ind. Informat., vol. 8, no. 2, pp. 241–254, May 2012.

[2]. C. Liu, K. T. Chau, and X. Zhang, "An efficient wind–photovoltaic hybrid generation system using doubly excited permanent-magnet brushless machine," IEEE Trans. Ind. Electron., vol. 57, no. 3, pp. 831–839, Mar. 2010.

[3]. M. P. Kazmierkowski, M. Jasinski, and G. Wrona, "DSP-based control of grid-connected power converters operating under grid distortions," IEEE Trans. Ind. Informat., vol. 7, no. 2, pp. 204–211, May 2011.

[4]. P. Palensky and D. Dietrich, "Demand side management: Demand response, intelligent energy systems, and smart loads," IEEE Trans. Ind. Informat., vol. 7, no. 3, pp. 381–388, Aug. 2011.

[5]. V. C. Gungor, D. Sahin, T. Kocak, S. Ergut, C. Buccella, C. Cecati, and G. P. Hancke, "Smart grid technologies: Communication technologies and standards," IEEE Trans. Ind. Informat., vol. 7, no. 4, pp. 529–539, Nov. 2011.

[6]. S. Wencong, H. Eichi, Z. Wente, and M.-Y. Chow, "A survey on the electrification of transportation in a smart grid environment," IEEE Trans. Ind. Informat., vol. 8, no. 1, pp. 1–10, Feb. 2012.

[7]. R. Teodorescu, M. Lissere, and P. Rodriguez, Grid Converter for Photovoltaic and Wind Power Systems. New York: Wiley, 2011.

[8]. E. Monmasson, L. Idkhajine, M. N. Cirstea, I. Bahri, A. Tisan, and M. W. Naouar, "FPGAs in industrial control applications," IEEE Trans. Ind. Informat., vol. 7, no. 2, pp. 224–243, May 2011.

[9]. L. S Yang and T. J. Liang, "Analysis and implementation of a novel bidirectional DC–DC converter," IEEE Trans. Ind. Electron., vol. 59, no. 1, pp. 422–434, Jan. 2012.

[10]. M. H. Nehrir, C. Wang, K. Strunz, H. Aki, R. Ramakumar, J. Bing, Z. Miao, and Z. Salameh, "A review of hybrid renewable/alternative energy systems for electric power generation: Configurations, control, and applications," IEEE Trans. Sustain. Energy, vol. 2, no. 4, pp. 392–402, Oct. 2011.

[11]. B. Singh, S. Singh, A. Chandra, and K. Al-Haddad, "Comprehensive study of single-phase AC–DC power factor corrected converters with high-frequency isolation," IEEE Trans. Ind. Informat., vol. 7, no. 4, pp. 540–556, Nov. 2011.

[12]. L. Barote and C. Marinescu, "Storage analysis for stand-alone wind energy applications," in Proc. IEEE OPTIM, 2010, pp. 1180–1185.

[13]. L. Barote, R. Weissbach, R. Teodorescu, C. Marinescu, and M. Cirstea, "Stand-alone wind system with vanadium redox battery energy storage," in Proc. IEEE OPTIM, 2008, pp. 407–412.

[14]. B. Fleck and M. Huot, "Comparative life-cycle assessment of a small wind turbine for residential off-grid use," J. Renewable Energy, vol. 34, no. 12, pp. 2688–2696, Dec. 2009.

[15]. M. J. Vasallo, J.M. Andújar, C. Garcia, and J. J. Brey, "A methodology for sizing backup

fuel-cell/battery hybrid power systems," IEEE Trans. Ind. Electron., vol. 57, no. 6, pp. 1964–1975, Jun. 2010.

[16]. M. Swierczynski, R. Teodorescu, C. N. Rasmussen, P. Rodriguez, and H. Vikelgaard, "Overview of the energy storage systems for wind powerintegration enhancement," in Proc. IEEE ISIE, 2010, pp. 3749–3756.

[17]. C. Abbey, L. Wei, and G. Joós, "An online control algorithm for application of a hybrid ESS to a wind–diesel system," IEEE Trans. Ind. Electron., vol. 57, no. 12, pp. 3896–3904, Dec. 2010.

[18]. R. C. Harwood, V. S. Manoranjan, and D. B. Edwards, "Lead–acid battery model under discharge with a fast splitting method," IEEE Trans. Energy Convers., vol. 26, no. 4, pp. 1109–1117, Dec. 2011.

[19]. T. Ackermann, Wind Power in Power Systems. Chichester, U.K.: Wiley, 2005.

[20]. Y. Ming, L. Gengyin, Z. Ming, and Z. Chengyong, "Modeling of the wind turbine with a permanent magnet synchronous generator for integration," in Proc. IEEE Power Eng. Soc. Gen. Meeting, 2007, pp.

Author(s) brief bio

Vignesha.R received the B.E degree in Electrical Engineering from Visvesvaraya Technological University Belgaum, Karnataka, India during the academic year 2008, now currently PG scholar, pursuing M.Tech, area of specialization is Power Electronics under Kuppam Engineering College, Jawaharlal Nehru Technological University Anantapur, Andhra Pradesh, India.

Y. Damodharam has obtained his B.Tech in EEE from Kuppam Engineering College, affiliated to JNTUH in the year 2006. He has obtained M.Tech in power system emphasis on High Voltage Engineering from JNTU Kakinada in the year 2010. He has 7 years of Teaching experience. Currently working as Associate Professor in Kuppam Engineering College in the Department of EEE. His area of research is renewable energy sources, High Voltage engineering & power systems

CH. Jayavardhana Rao has obtained his B.Tech Electrical Engineering from JNTUH, Hyderabad in the year 2002, M.Tech in power system emphasis on High voltage engineering from JNTUK Kakinada in the year 2009. He has 5 years of industrial experience, 2 years of research experience and 7 years of Teaching experience. Currently working as Associate Professor in Department of Electrical Engineering at Kuppam Engineering College, Kuppam, Chittoor district, Andhra Pradesh, INDIA. His Area Of Research Includes Power Systems, Power Electronics, High Voltage Engineering, Renewable Energy Sources, Industrial Drives, HVDC & FACTS Technology.

Dr. Venugopal. N has obtained his doctoral degree from Dr. MGR. University Chennai. B.E. degree and M.E. Degree both from Bangalore University. He has 17 years of teaching experience. His research area is Digital Image Processing, Power Electronics, Renewable Energy Sources & Video sequence separation. He is Currently working as Professor and HOD of EEE Department & Director, R & D in Kuppam Engineering College, Kuppam, and Chittoor Dist. Andhra Pradesh. His research area of interest includes Power electronics, Renewable Energy Systems and Embedded Systems. He received AICTE & IEI grants for research Projects in the areas of Electrical Engineering.