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ADVANCED POWER CONTROL TECHNIQUES FOR HYBRID WIND-POWER GENERATION SYSTEM USED IN STANDALONE APPLICATION

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Abstract— This paper proposes a unique standalone hybrid power generation system, applying advanced power control techniques, feed by four power sources: wind power, solar power, storage battery, and diesel engine generator, and which is not connected to a commercial power system. This design allows the two sources to supply the load separately or simultaneously depending on the availability of the energy sources. Dissimilar power sources can be organized anyplace on the equal power line, leading to bendy system expansion. Simulation results are provided in the paper to demonstrate the capabilities of the system.
Keywords: Standalone hybrid power generation system, dump power control, storage battery, MATLAB.

I. Introduction

NATURAL energy-based power generation systems are commonly set with storage batteries, to regulate output fluctuations resulting from natural energy variation. Therefore, it is necessary to prevent battery overcharging. As for the utility connected hybrid generation system consisting of a wind power, a solar power, and battery, the dump power is able to control to prevent overcharging the battery without dump load because of dump power transferred into the utility [1]. As for the individual power generation system, it is considered that a PV system featuring low-cost and simple control, which incorporates maximum power point tracking control that makes use of diode character [2], or a PV system that features output stability with a multiple-input dc–dc converter capable of controlling the output of different power sources in combination [3], or a cascaded dc–dc converter PV system that features good efficiency along with low cost [4], or a wind turbine system that features output stability with a combination of an electric double-layer capacitor and storage battery [5], is suitable for use with hybrid power generation systems to stabilize power supply. In contrast, the standalone hybrid system is mainly composed of natural energy sources (i.e., wind power and solar power), and a storage battery; and in some cases, a diesel engine generator may be incorporated into the system as well. However, there is a tendency that the greater the system sophistication, the more suitable the power control techniques are required to be.

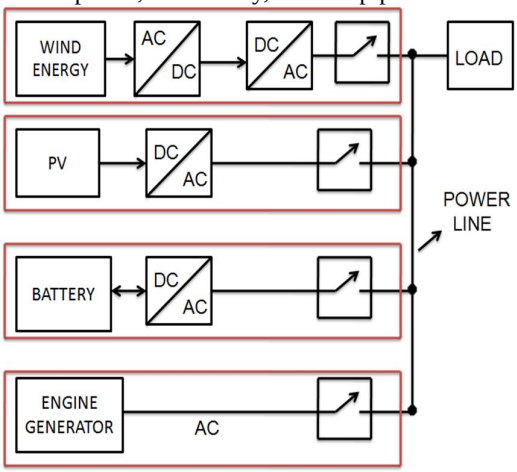

Fig.1. Standalone hybrid wind-solar power generation system with storage battery.

A dc–dc converter is mounted in both wind power and solar power generation systems. The two systems are interconnected at the output sides of individual converters and are also connected to the storage battery. In such a configuration, each dc–dc converter is capable of monitoring the current and voltage of the storage battery, and optimally controlling battery charging, to supply power to the load [6]–[10]. In most cases where converters and storage batteries are set up at a centralized location, the storage batteries are commonly installed adjacent to the wind- and solar-power generation systems; therefore, there is generally no freedom to install the batteries on flat ground or in places with good vehicular access for easy maintenance and replacement.

In a hybrid system with a storage battery, as shown in Fig. 1, the output of dc–dc converters is sent to an external dc–ac inverter to supply ac power to load. Therefore, a future increase in load will

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require an increase in inverter capacity [7]–[10]. In a system

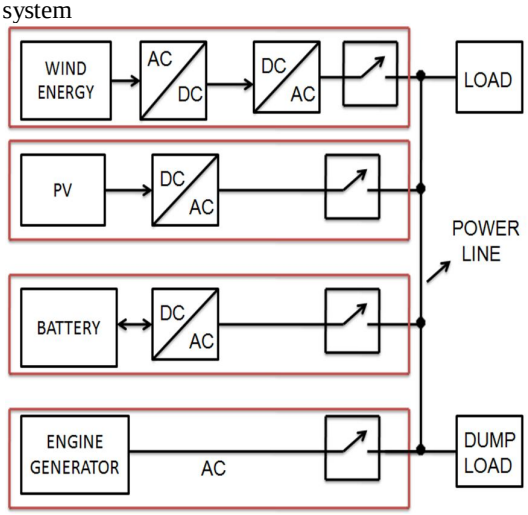

Fig.2. Existing standalone hybrid wind-solar power generation system with dump load.

applying a dispersed inverter setup, as shown in Fig. 2, individual wind- and solar power generation systems, each mounted with a dc–ac converter, are interconnected in parallel at the inverter output sides and are also connected to a diesel engine generator via a power line. At the same time, a dump load is also mounted on the same power line [11]–[13]. In this case, a storage battery is installed within the solar power generation system, and dump power is controlled as necessary to prevent battery overcharging. Several different techniques to prevent battery overcharging are widely used. For instance, the battery is installed adjacent to the wind power generation system and a solid-state relay or power device is used as control switch of dump load [14]–[15]. Another technique is that surplus power is consumed by a hydrogen generator for a fuel battery instead of storage battery, and when the hydrogen tank becomes full, dump load is applied. While these techniques construct a dispersed installation of different power sources, installation of dump load is necessary. Further, a dedicated high-speed line for battery current/voltage status data transmission, or otherwise a high-tech dump load control method, is necessary. To resolve these problems, the authors have proposed a low cost, standalone hybrid wind-solar power generation system applying advanced power control techniques. This system has the following features: 1) dispersed installation of different power sources that are interconnected in parallel; 2) elimination of dump load by using a unique dump power control aimed at prevention of battery overcharging; 3) no need for dedicated high-speed line for battery current/voltage status data transmission; and 4) easy capacity expansion through parallel connection of additional power sources to cope with future load increases.

Special attention has also been given to phased locked loop (PLL) control techniques. Through laboratory experiments, we investigated the behavior of current/voltage waves by inputting active-reactive power parameters into an experimental power control circuit and demonstrated a valid power control effect.

II. System Summary

A.System Topology

The proposed standalone hybrid wind-solar power generation system is, as shown in Fig. 3, in outline composed of four power sources: a wind power generation system (with a WT converter and a WT inverter), solar power generation system (with a PV inverter), storage battery (with a bidirectional inverter), and engine generator (EG); and a control unit. The control unit acts to send ON/OFF operation commands to individual power sources and monitor power status via a simple communication line, which is all that is needed since the data traffic volume is small. Once an ON command is sent, each power source is autonomously operated via individual inverters; however, manual setting of inverter operating conditions is also possible if required. The inverters enable redundant parallel operation, making a reliable, stable power supply possible.

B.System Operation

Major operation flows of the proposed hybrid system, as shown in Fig. 3 & 4, are as follows.

1) When the remaining battery capacity is sufficient: EG operation stops, and all inverters operate in parallel. Power surplus and deficit according to the balance between the output and load can be optimally adjusted through battery charging or discharging.

2) When the remaining battery capacity is insufficient: EG and all inverters operate in parallel. When power generated by wind and solar power generation system is insufficient to meet load demand, EG compensates for the deficiency. Concurrently, EG charges the battery via the bidirectional inverter. This inverter regulates charging power for the battery so that EG can be operated at the optimal load factor matching

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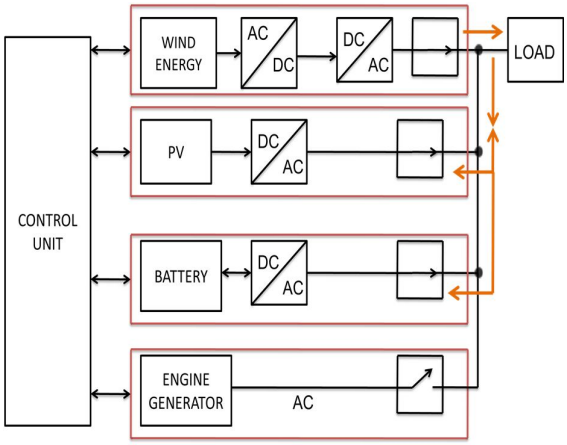


Fig.3. Proposed standalone hybrid wind-solar power generation system operation flow when remaining battery capacity is sufficient.

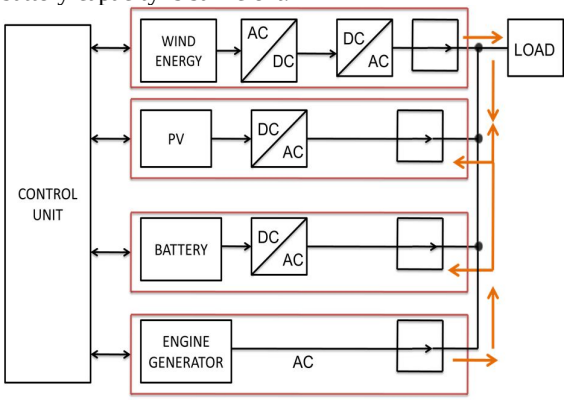


Fig.4. System operation flow when remaining battery capacity is insufficient.

with high efficiency, following a command from the control unit.

III. Dump Power Control Technique

When either wind power or solar power generation becomes greater than load, EG stops. When there is no dump power, the inverter acts only with ac output voltage reference. In Fig. 5, in case the larger of the outputs from dc over current detection circuit and dc overvoltage detection circuit exceeds the ac output voltage reference, the diode

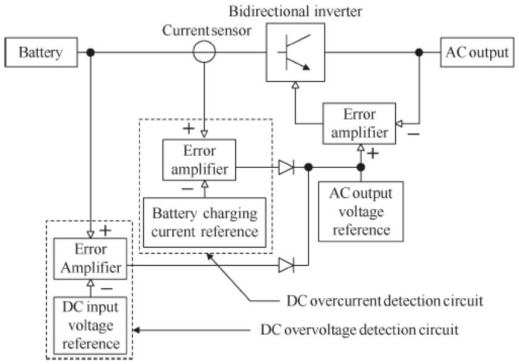


Fig.5. Dump power control block diagram of the bidirectional inverter.

related to the error amplifier with the larger output is turned on. Then, dc over current value or dc overvoltage value is added to the ac output voltage reference; thus, the inverter acts.

IV. Simulation and Result

The block diagram of the hybrid wind solar power generation system used in the experimental setup is shown in Figure 6.

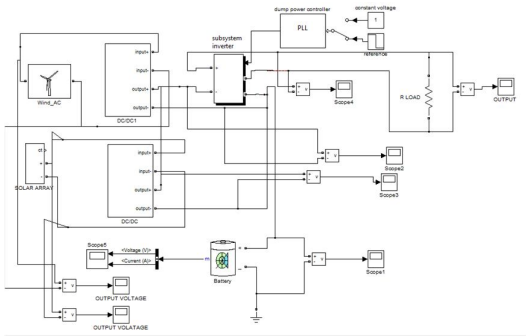
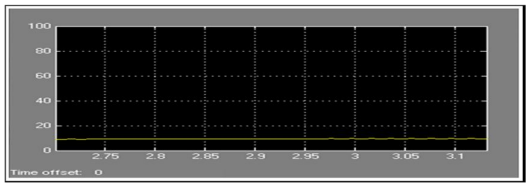


Fig. 6. Hybrid wind solar system model built with MATLAB/SIMULINK .

Here the wind and solar generation system connected in parallel type with storage battery. When the battery goes to be at peak condition occurs then the PLL controller disconnecting any one of the source.



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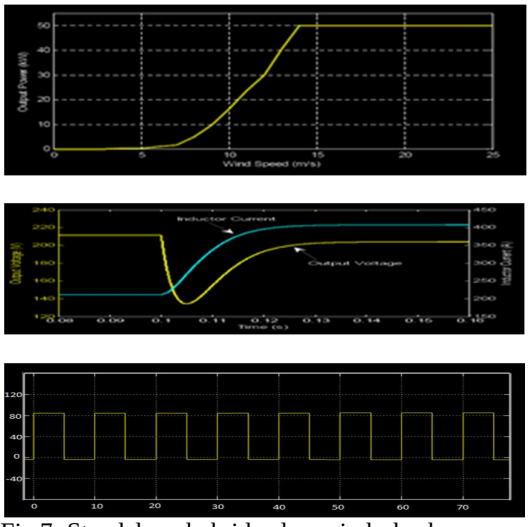

Fig.7. Standalone hybrid solar, wind, dc chopper and inverter output power characteristic.

.IV. CONCLUSION

This paper have proposed a unique standalone hybrid wind solar power generation system, which is characterized by dump power control. In dump power control allows for formation of a feedback loop in this system, meaning that there is no requirement for a dedicated high-speed line to transmit storage battery voltage and current data. In case the power line is used as a media for data transmission, the line voltage amplitudes can be applied as a means of data transmission; thus, there is no requirement for installation of any optical fiber transmission line or power line carrier system through which harmonic signals are applied to power line. In addition, neither dump load nor dump load control device are necessary. Under our dump power control, regulation of output is done without battery overcharging, and effective use of surplus power is made possible. This contributes to battery life extension and realization of a low-cost system. The system, through ac system interconnection, will also allow flexible system expansion in the future. Further, power sources including EG can be flexibly interconnected anywhere through the same power line, and power quality stability can be maintained by controlling the phase and amplitude of ac output voltage. It is expected that this hybrid system into which natural energy is incorporated, and which makes use of various power control techniques, will be applicable in rural locations, even those with poor communications media. The system will also contribute to global environmental protection through application on isolated islands without any dependence on commercial power systems.

REFERENCES

[1] S.-K. Kim, J.-H. Jeon, C.-H. Cho, J.-B. Ahn, and S.-H. Kwon, "Dynamic modeling and control of a grid-connected hybrid generation system with versatile power transfer," *IEEE Trans. Ind. Electron.*, vol. 55, no. 4,pp. 1677–1688, Apr. 2008.

[2] K. Kobayashi, H. Matsuo, and Y. Sekine, "An excellent operating point tracker of the solar-cell power supply system," *IEEE Trans. Ind. Electron.*, vol. 53, no. 2, pp. 495–499, Apr. 2006.

[3] K. Kobayashi, H. Matsuo, and Y. Sekine, "Novel solar-cell power supply system using a multiple-input dc–dc converter," *IEEE Trans. Ind. Electron.*, vol. 53, no. 1, pp. 281–286, Feb. 2006.

[4] A. I. Bratcu, I. Munteau, S. Bacha, D. Picault, and B. Raison, "Cascaded dc–dc converter photovoltaic systems: Power optimization issues," *IEEE Trans. Ind. Electron.*, vol. 58, no. 2, pp. 403–411, Feb. 2011.

[5] W. Li, G. Joos, and J. Belanger, "Real-time simulation of a wind turbine generator coupled with a battery supercapacitor energy storage system," *IEEE Trans. Ind. Electron.*, vol. 57, no. 4, pp. 1137–1145, Apr. 2010.

[6] F. Valenciaga and P. F. Puleston, "Supervisor control for a stand-alone hybrid generation system using wind and photovoltaic energy," *IEEE Trans. Energy Convers.*, vol. 20, no. 2, pp. 398–405, Jun. 2005.

[7] S. Meenakshi, K. Rajambal, C. Chellamuthu, and S. Elangovan, "Intelligent controller for a stand-alone hybrid generation system," in *Proc. IEEE Power India Conf.*, New Delhi, India, 2006.

[8] R. Belfkira, O. Hajji, C. Nichita, and G. Barakat, "Optimal sizing of stand-alone hybrid wind/pv system with battery storage," in *Proc Power Electron. Appl. Eur. Conf.*, Sep. 2007, pp. 1–10.

[9] S. Wang and Z. Qi, "Coordination control of energy management for stand-alone wind/pv hybrid systems," in *Proc. IEEE ICIEA*, May 2009, pp. 3240–3244.

[10] 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.

[11] F. Bonanno, A. Consoli, S. Lombardo, and A. Raciti, "A logistical model for performance evaluations of hybrid generation systems," *IEEE Trans. Ind. Appl.*, vol. 34, no. 6, pp. 1397–1403, Nov./Dec. 1998.

[12] M. H. Nehrir, B. J. LaMeres, G. Venkataramanan, V. Gerez, and L. A. Alvarado, "An approach to evaluate the general performance of

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[13] J. M. Carrasco, L. G. Franquelo, J. T. Bialasiewicz, E. Galvan, R. C. P. Guisado, M. A. M. Prats, J. I. Leon, and N. Moreno-Alfonso, "Power-electronic systems for the grid integration of renewable energy sources: A survey," *IEEE Trans. Ind. Electron.*, vol. 53, no. 4, pp. 1002–1016, Jun. 2006.

[14] S. Jiao, G. Hunter, V. Ramsden, and D. Patterson, "Control system design for a 20 kW wind turbine generator with a boost converter and battery bank load," in *Proc. PESC*, Sep./Oct. 2001, pp. 2203–2206.

[15] S. Tanezaki, T. Matsushima, and S. Muroyama, "Stand-alone hybrid power supply system composed of wind turbines and photovoltaic modules for powering radio relay stations," in *Proc. IEEE INTELEC*, Oct. 2003, pp.457–462.2006