A New Proposal for Standalone Applications in DG

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Abstract— *We have several applications in wind energy generating systems as standalone and grid connected systems However, wind flow by nature is intermittent. In order to provide the continues operation we are using a backup technology for storing. In this paper, the sustainability of a hybrid of wind and battery system is investigated for meeting the requirements of a stand-alone dc load. A charge controller for battery bank based on turbine maximum power point tracking and battery state of charge is developed to ensure controlled charging and discharging of battery.*

Keywords— DG, Standalone Applications

I. INTRODUCTION

Energy is the considered to be the pivotal input for development. At present owing to the depletion of available conventional resources and concern regarding environmental degradation, the renewable sources are being utilized to meet the ever increasing energy demand. Due to a relatively low cost of electricity production wind energy is considered to be one of the potential sources of clean energy for the future. But the nature of wind flow is stochastic. So rigorous testing is to be carried out in laboratory to develop efficient control strategy for wind energy conversion system (WECS). The study of WECS and the associated controllers are, thus, becoming more and more significant with each passing day.

We have several generating systems with WECS technology as analysis of the available storage technologies for wind power application. The advantage of battery energy storage for an isolated WECS is discussed .With battery energy storage it is possible to capture maximum power from the available wind. A comparison of several maximum power point tracking (MPPT) algorithms for small wind turbine (WT) is carried out .In order to extract maximum power form WECS the turbine needs to be operated at optimal angular speed .However, do not take into account the limit on maximum allowable battery charging current nor do they protect against battery overcharging. With battery energy storage it is possible to capture maximum power from the available wind. A comparison of several maximum power point tracking (MPPT) algorithms for small wind turbine (WT) is carried and. In order to extract maximum power form WECS the turbine needs to be operated at optimal angular speed. However do not take into account the limit on maximum allowable battery charging current nor do they protect against battery overcharging. In order to observe the charging limitation of a battery a charge controller is required

In this paper A hybrid wind-battery system is considered to meet the load demand of a stand-alone base telecom station (BTS). The BTS load requirement is modeled as a dc load which requires a nominal regulated voltage of 50 V. The WECS is interfaced with the stand-alone dc load by means of ac–dc–dc power converter to regulate the load voltage at the desired level.that MPPT schemes with and without battery charging mode control and pitch control technique have been implemented independently for stand-alone wind energy applications.

The proposed control scheme utilizes the turbine maximum power tracking technique with the battery SoC limit logic to charge the battery in a controlled manner. Unlike, the MPPT logic used here actually forces the turbine to operate at optimum TSR and hence is parameter independent. The battery charging current is always continuous with very low ripple thus avoiding harmonic heating. The changeover between the modes for battery charging is affected based on the actual value of the SoC. Further it also provides protection against turbine over speed, over loading, and over voltage at the rectifier output by using pitch control.

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The fallowing advantages will be ensured from the proposed control technique

- efficient to ensure continuous power flow to the load
- maximum power is extracted from WECS at all wind speeds to meet the load requirement
- the pitch control logic guarantees that the rectifier voltage does not lead to an overvoltage situation.
- Overall efficiency is improved.

II. SYSTEM DECEPTION

The proposed system configuration as fallows it consists of WES (Wind energy system) MPPT(maximum power point tracking) Storage system

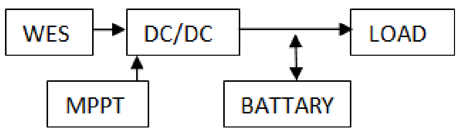


Fig. 1: system configuration

A. MPPT

There are commericially available MPPTs which are typically used for home solutions and buildings. These are not designed to withstand the harsh, fast-changing environmental conditions of solar car racing. Design of the customized MPPT will ensure that the system operates as closely to the Maximum Power Point (MPP) while being subjected to the varying lighting and temperature

The inputs of the MPPT consisted of the photovoltaic voltage and current outputs. The adjusted voltage and current output of the MPPT charges the power supply. See Figure 2.

A microcontroller was utilized to regulate the integrated circuits (ICs) and calculate the maximum power point, given the output from the solar array. Hardware and software integration was necessary for the completion of this component.

Many factors influenced the component selection and the design of the MPPT.

- In terms of optimal functionality, the theory of power conservation needed to be applied. The input and output voltage and current were calculated such that the power into and out of the MPPT was equal.
- To protect the photovoltaic array from damage, protection diodes were employed.
- Two 48V lead acid battery banks were utilized. Only one battery bank will be charged at a time. (The other will be employed to run other components of the car).
- In order to trickle charge the batteries, a voltage exceeding 48V must be fed to the bank. In this design, 50V was chosen to charge the power supply.
- To prevent damage and overcharging of the power supply, a FET was employed.

III. Modes of Operations

A. *Modes of Operation*

1) *CC Mode of Battery Charging*

In CC mode, the battery charging current demand is determined from the MPPT logic. MPPT is implemented by comparing the actual and optimum TSR (λopt). The error is tuned by a PI controller to generate the battery charging current as per the wind speed. In this mode, the converter output voltage rises with time while the MPPT logic tries to transfer as much power as possible to charge the batteries. The actual battery charging current that can be achieved does not remain constant but varies with available wind speed subject to a maximum of C/10 rating of the battery. The battery charging current command has a minimum limit of zero. In case the wind speed is insufficient to supply the load even with zero battery charging current the inductor current reference is frozen at that particular value and the balance load current is supplied by the battery.

2) *CV Mode of Battery Charging*

In the CC mode, the battery voltage and SoC rise fast with time. However, the charge controller should not overcharge the batteries to avoid gasification of electrolyte. As a result, once the battery SoC becomes equal to the reference SoC the controller must switch over from CC mode to CV mode. In CV mode, the battery charging voltage(V0) is determined from the buck. The value of the converter voltage when the battery SoC reaches 98% is set as the reference value and is compared with the actual converter output voltage. The error in the voltage is then controlled by a cascaded arrangement of PI controller and lead compensator to generate the inductor current reference. It is then compared with the actual inductor current by a logical comparator to generate gate pulses in a similar way as described in Section A. In this mode, the converter output voltage is maintained at a constant value by the controller action. So, in CV mode the battery voltage and SoC rise very slowly with time as compared to CC mode.

The battery charging current slowly decreases with time, since the potential difference between the buck converter output and battery terminal gradually reduces. converter output voltage The battery is charged both in CC mode and CV mode. The transition from CC to CV mode takes place when the battery SoC reaches 98%. This is because in the present design, the threshold SoC for switch over in the control logic is set at 98%. As discussed in the earlier section, in the CC mode the battery charges at a CC of 40 A which is the C/10 value for a 400-Ah battery bank. During this mode, both converter output voltage and battery voltage rise. The battery SoC rises from an initial SoC level of 97.95% to 98% within 17 s. As the battery reaches the threshold SoC level, the buck converter voltage is regulated by the controller action at a constant value of 53 V while the converter current gradually reduces from 40 A at 17 s to 10 A at 40 s. The battery SoC slowly rises from 98% to 98.03%. The results indicate that the battery charges at a faster rate in CC mode as compared to CV mode. Thus, in CC mode much of the available power from primary source is injected into the battery whereas in CV mode the battery is charged slowly to avoid gasification and heating issue.

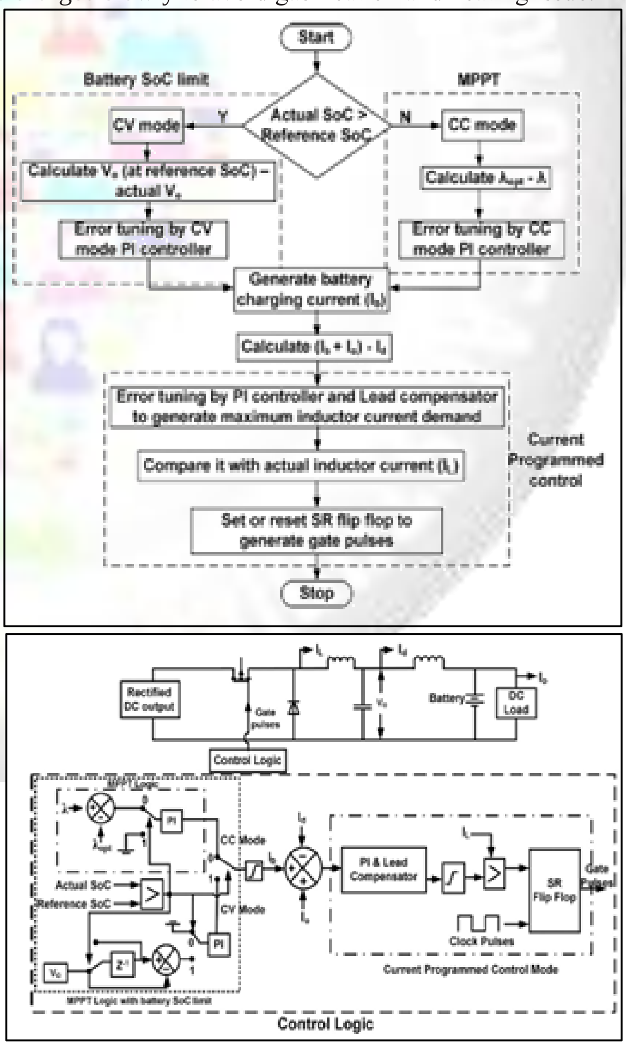


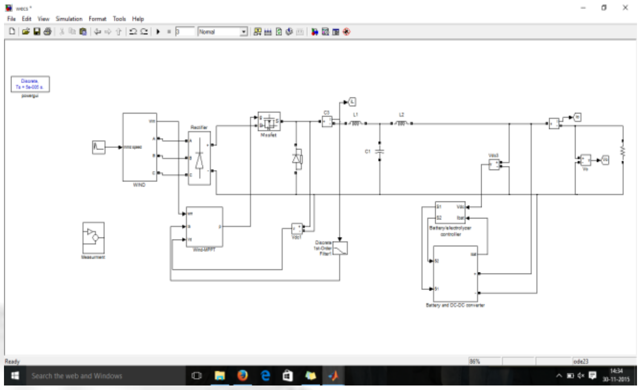
Fig. 2: Circuit Diagram

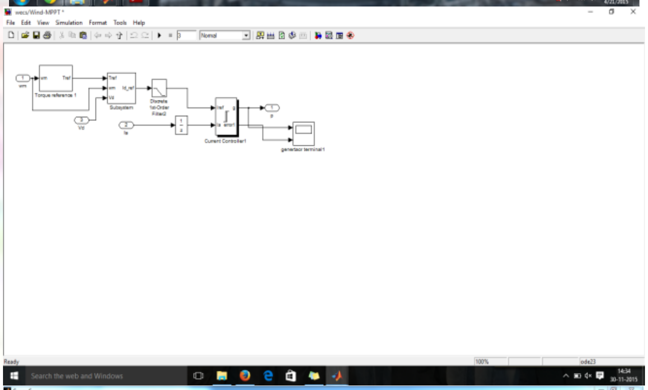
IV. RESULTS AND DISCUSSIONS

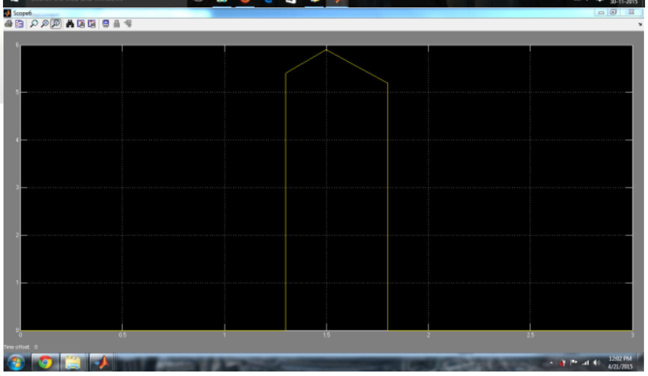
A WECS needs to be efficient to ensure continuous power flowto the load. The effectiveness can be achieved by integrating the hybrid wind-battery system with suitable control logic. This includes the charge control logic and the pitch control logic. The charge controller regulates the charging and discharging rate of the battery bank while the pitch controller controls the WT action during high wind speed conditions or in case of a power mismatch. Both the control strategy are integrated with the hybrid system and simulated with various wind profiles to validate the efficacy of the system. The system is connected to a load profile varying in steps from 0 to 4 kW. The WT parameters like shaft speed, TSR, blade pitch and output power are analyzed with variation in wind speed conditions. The current profile of the converter, load, and the battery are also monitored with the wind profile. To ensure uninterrupted power flow, load demand is given more priority over battery charging. The WT and battery parameters are observed for the following wind profiles.

– Gradual rise and fall in wind speed.
– Step variation in wind speed.
– Arbitrary variation in wind speed.

A gradual rise and fall in wind speed as shown in Fig. 8(a) is applied to the WT. The wind speed gradually rises from 8 to 12 m/s in 15 s and then falls to 8 m/s in the next 15 s. The WT parameters and the current profile of the converter, load and thebattery are observed in Fig. 8(a) and (b). Further the efficacy of the complete control scheme is validated with a step variation in wind profile and an arbitrary varying wind speed. The variation of the wind profile in step from 8 to 12 m/s is shown in Fig. 9(a) while the arbitrary variation in wind speed from 6 to 14 m/s is highlighted in Fig 10(a). The response of WT parameter and the current profiles with respect to step variations and arbitrary variations are shown in Figs. 9 and 10, respectively. The results also demonstrate the change in battery SoC for all possible wind profiles. From Figs 8–10, it is observed, that when the wind speed is below the rated value (10 m/s) the MPPT scheme regulates the TSR of WT at its optimum value irrespective of the variation in wind profile. Thus maximum power is extracted from WECS at all wind speeds to meet the load requirement and charge the battery bank. But, the wind power is not always sufficient to meet the load demand and charge the battery in CC mode. In such situations the system first meets the load requirement and charges the battery bank at a reduced rate. Moreover, when thewind power is not adequate as per the load demand, the battery discharges to meet the deficit. The battery SoC increases during charging but decreases while discharging. However, the charge controller ensures that the battery current during charging or discharging never exceeds 40 A. The pitch angle of WT is maintained at zero deg at wind speed below 10 m/s. But the pitch controller is activated as the wind speeds exceeds its rated limit. The increase in the pitch angle limits the power and speed output within the safe limits of WT operation. The response of WT and currents for all possible variations in wind profile indeed prove the efficacy of the proposed control logic for thehybrid wind–battery system.







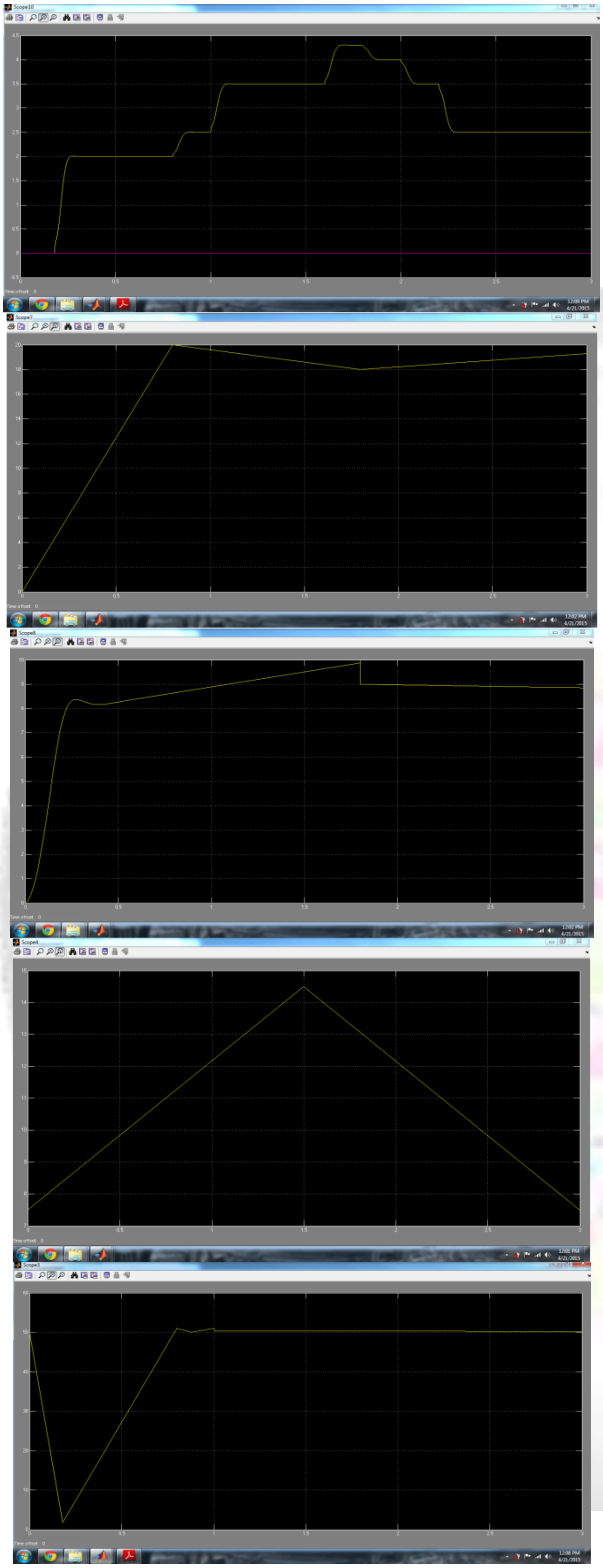


Fig. 3: The characteristics of wind system and battery system under different wind speeds

V. Conclusion

The power available from a WECS is very unreliable in nature. So, a WECS cannot ensure uninterrupted power flow to the load. In order to meet the load requirement at all instances, suitable storage device is needed. Therefore, in this paper, a hybridwind-battery system is chosen to supply the desired load power. To mitigate the random characteristics of wind flow the WECS is interfaced with the load by suitable controllers. The control logic implemented in the hybrid set up includes the charge control of battery bank using MPPT and pitch control of the WT for assuring electrical and mechanical safety. The charge controller tracks the maximum power available to charge the battery bank in a controlled manner. Further it also makes sure that the batteries discharge current is also within the C/10 limit. The current programmed control technique inherently protects the buck converter from over current situation. However, at times due to MPPT control the source power may be more as compared to the battery and load demand. During the power mismatch conditions, the pitch action can regulate the pitch angle to reduce the WT output power in accordance with the total demand. Besides controlling the WT characteristics, the pitch control logic guarantees that the rectifier voltage does not lead to an overvoltage situation. The hybrid wind-battery system along with its control logic is developed in MATLAB

References

[1] A. D. Sahin, "Progress and recent trends in wind energy," Progress in Energy Combustion Sci., vol. 30, no. 5, pp. 501–543, 2004.

[2] R. D. Richardson and G. M. Mcnerney, "Wind energy systems," Proc. IEEE, vol. 81, no. 3, pp. 378–389, Mar. 1993.

[3] R. Saidur, M. R. Islam, N. A. Rahim, and K. H. Solangi, "A review on global wind energy policy," Renewable Sustainable Energy Rev., vol. 14, no. 7, pp. 1744–1762, Sep. 2010.

[4] M. T. Ameli, S. Moslehpur, and A. Mirzale, "Feasibility study for replacing asynchronous genrators with synchronous generators in wind farm power stations," in Proc. IAJC – IJME, Int. Conf. Eng. Technol.,Music City Sheraton, Nashville, TN, US, ENT paper 129Nov. 17–19, 2008.

[5] G. K. Singh, "Self excited generator research—A survey," Electric Power Syst. Res., vol. 69, no. 2/3, pp. 107–114, 2004.

[6] R. C. Bansal, "Three-phase self-excited induction generators: An overview," IEEE Trans. Energy Convers., vol. 20, no. 2, pp. 292–299, Jun. 2005.

[7] S. C. Tripathy, M. Kalantar, and N. D. Rao, "Wind turbine driven self excited induction generator," Energy Convers. Manag., vol. 34, no. 8, pp. 641–648, 1993.

[8] A. Chakraborty, "Advancements in power electronics and drives in interface with growing renewable energy resources," Renewable Sustainable Energy Rev., vol. 15, no. 4, pp. 1816–1827, May 2011.

[9] F. D. Gonzalez, A. Sumper, O. G. Bellmunt, and R. V. Robles, "A review of energy storage technologies for wind power applications," Renewable Sustainable Energy Rev., vol. 16, no. 4, pp. 2154–2171, May 2012.

[10] N. S. Hasan, M. Y. Hassan, M. S. Majid, and H. A. Rahman, "Review of storage schemes for wind energy systems," Renewable Sustainable Energy Rev., vol. 21, pp. 237–247, May 2013.

[11] A. M. D. Broe, S. Drouilhet, and V. Gevorgian, “A peak power tracker for small wind turbines in battery charging applications,” IEEE Trans. Energy Convers., vol. 14, no. 4, pp. 1630–1635, Dec. 1999.
[12] R. Kot, M. Rolak, and M. Malinowski, “Comparison of maximum peak power tracking algorithms for a small wind turbine,” Math. Comput. Simul., vol. 91, pp. 29–40, 2013.
[13] M. Narayana, G. A. Putrus, M. Jovanovic, P. S. Leung, and S. McDonald, “Generic maximum power point tracking controller for small-scale wind turbines,” Renewable Energy, vol. 44, pp. 72–79, Aug. 2012.