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# Control and Operation of a DC Grid-Based Wind Power Generation System in Micro Grid

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**ABSTRACT**

This article presents a Microgrid consisting of different wind power stations are connected to the distribution gird. The proposed microgrid allows flexible operation of multiple parallel connected wind generators by eliminating the need for voltage and frequency synchronization. The control design for distributed generation inverters employs new model predictive control algorithm, which enables faster computational time for large power systems by optimizing the steady state and transient control problems separately. The integration of renewable sources can supplement in their generation and might compromise the reliability and stability of distribution network. As a result, energy storage devices such as batteries and ultra-capacitors are required to compensate for the variability in the renewable sources. The incorporation of energy storage devices is also critical for managing peak demands and variation in load demand. In this project, micro gird consisting of multiple parallel connected wind generators and lithium ion batteries are proposed. The proposed controller for distributed generation inverter is based on newly developed model predictive control algorithm, which decomposes the control problem into steady state and transient sub problems in order to reduce the overall computation time.

***Keywords:*** *Wind power generation, dc grid, energy managemnt, model predictive control*

## I. INTRODUCTION

The increasing application of nonlinear loads can led to significant harmonic pollution in a power distribution system. The harmonic distortion may excite complex resonances, especially in power systems with underground cables or subsea cables. In fact, these cables with nontrivial parasite shunt capacitance can form an LC ladder network to amplify resonances. In order to mitigate system resonances, damping resistors or passive filters can be placed in the distribution networks. Nevertheless, the mitigation of resonance propagation using passive components is subject to a few well understood issues, such as power loss and additional investment. Moreover, a passive filter may even bring additional resonances if it is designed or installed without knowing detailed system configurations. To avoid the adoption of passive damping equipment, various types of active damping methods have been developed. Among them, the resistive active power filter (R-APF) is often considered as a promising way to realize better performance. Conventionally, the principle of R-APF is to emulate the behavior of passive damping resistors by applying a closed-loop current controlled method (CCM) to power electronics converters. In this control category, the RAPF can be simply modeled as a virtual harmonic resistor if it is viewed at the distribution system level.

Additionally, a few modified R-APF concepts were also developed in the recent literature. In the discrete tuning method was proposed to adjust damping resistances at different harmonic orders. Accordingly, the R-APF essentially works as a nonlinear resistor. In the operation of multiple R-APFs was also considered, where an interesting droop control was designed to offer autonomous harmonic power sharing ability among parallel R-APFs. On the other hand, renewable energy source (RES) based distributed generation (DG) units have been adopted to form flexible micro grids and their interfacing converters also have the opportunity to address different distribution system power quality issues. For current controlled DG units, the auxiliary R-APF function can be seamlessly incorporated into the primary DG real power injection function by modifying the current reference. However, conventional CCM can hardly provide direct voltage support during micro grid islanding operation. To overcome this limitation, an enhanced voltage-controlled method (VCM) was recently proposed for DG units with high-order LC or LCL filters. It can be seen that the control method in regulates the DG unit as virtual impedance, which is dependent on the existing feeder impedance. When the feeder impedance is inductive, this method could not provide enough damping effects to system resonance. To achieve better operation of grid connected and islanding micro grids, the paper considers a simple harmonic propagation model in which the micro grid is placed at the receiving end of the feeder. To mitigate the feeder harmonic distortions, a modified virtual impedance-based active damping method that consists of a virtual resistor and a virtual nonlinear capacitor is also proposed. The virtual capacitor eliminates the impacts of LCL filter grid-side inductor and the virtual resistor is interfaced to the receiving end of the feeder to provide active damping

## II. Literature Survey

Below could be a literature review of works distributed in previous few years in Grid-Connected and Islanding Micro grids

[1] **"Consideration of a shunt active filter based on voltage detection for installation on a long distribution feeder," by K. Wada, H. Fujita, and H. Akagi-**This paper deals with a curious phenomenon referred to as the "whack-a-mole" that may occur in a long-distance distribution feeder having many capacitors for power factor correction.

[2] **"Design of a new cooperative harmonic filtering strategy for distributed generation interface converters in an islanding network,"** by T.-L. Lee and P.-T. Cheng, -This paper have shown increasing demand for premium electric power, in terms of both quality and reliability, and emerging new energy technologies have led to the development of distributed generation systems.

[3] **"Design, analysis and real time testing of a controller for multibus microgrid system,"** by Y.W. Li, D. M. Vilathgamuwa, and P. C. Loh -This have shown the design and analysis of a controller for multibus micro grid system.The controller proposed for use with each distributed generation (DG) system in the microgrid contains inner voltage and current loops for regulating the three-phase grid-interfacing inverter, and external power control loops for controlling real and reactive power flow and for facilitating power sharing between the paralleled DG systems when a utility fault occurs and the microgrid islands.

[4] **"Analysis, design and implementation of virtual impedance for power electronics interfaced distributed generation,"** by J. He and Y. W. Li,- This paper presents a virtual impedance design and implementation approach for power electronics interfaced distributed generation (DG) units. To improve system stability and prevent power couplings, the virtual impedances can be placed between interfacing converter outputs and the main grid.

[5] **"An accurate power control strategy for power electronics- interfaced distributed generation units operating in a low voltage multibus micro grid,"** by Y. W. Li and C. N. Kao- In this paper, a power control strategy is proposed for a low-voltage micro grid, where the mainly resistive line impedance, the unequal impedance among distributed generation (DG) units, and the micro grid load locations make the conventional frequency and voltage droop method unpractical.

[6] **"Harmonic mitigation throughout a distribution system: A distributed-generator-based solution," N**. Pogaku and T. C. Green,- This paper investigates the use of ancillary services from inverter-interfaced distributed generators (DGs) to achieve harmonic mitigation across a network. The approach is to include the functionality of a resistive active-power filter (R-APF) within several DGs.

## III. Proposed System

Topology of non-grid-connected wind energy conversion system this paper discussed is shown in Fig.6.1. PMSG that with PWM voltage source vector control which can enable a high energy efficiency by adjusting the rotational speed, is directly driven by a fixed pitch wind turbine, DC bus voltage is constant under the control of Boost converter which ensures the power balance of the system, Buck converter is introduced to maintain the output voltage a constant. The basic control strategy is to achieve maximum peak power tracking of wind turbine while operating in below rated power condition and to limit the power while operating in the above rated power condition.

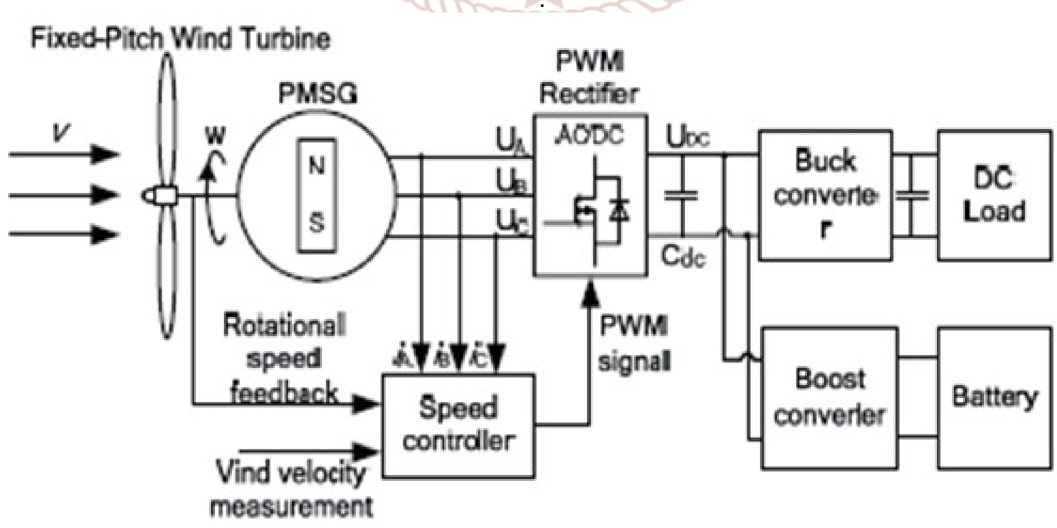


Fig 1.Block Diagram of Proposed System

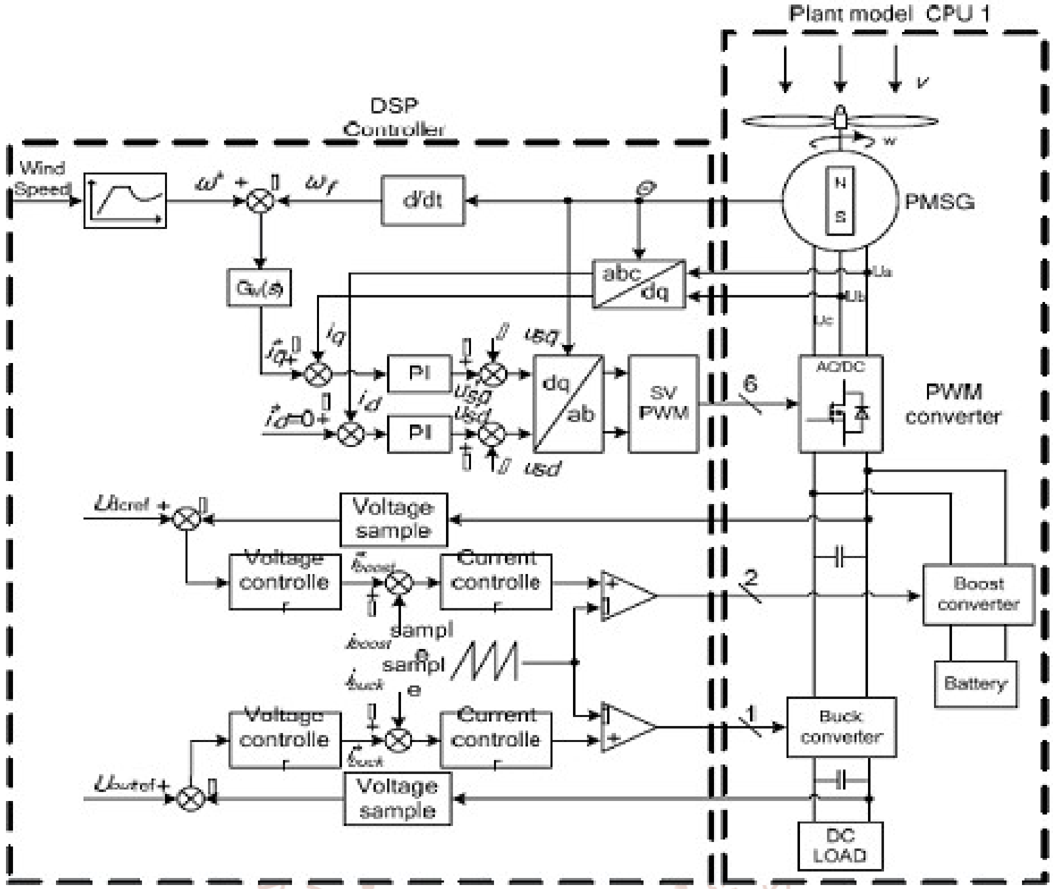


Fig.2. Structure of the direct drive non-grid-connected wind energy conversion system

Fig.2 represents the structure of the direct drive non grid- connected wind energy conversion system. The virtual plant simulation model, including wind speed, fixed pitch wind turbine, PMSG, PWM converter, Buck converter, Boost converter, Battery and load is distributed to simulator core. Plant speed control, vector control of PMSG, average current-mode control of DC-DC converters are accomplished in real DSP controller.

If the control strategy is well designed, the plant will work properly, and the wind generator controllers under test behave as if they were connected to the real system, the tested controller can therefore be tested over a wide range of parameters without risk to the main system.

## IV. Simulation Circuit Diagram

The performance of the proposed system has been validated through MATLAB and associated toolbox "SIMULINK" and "Power System Block

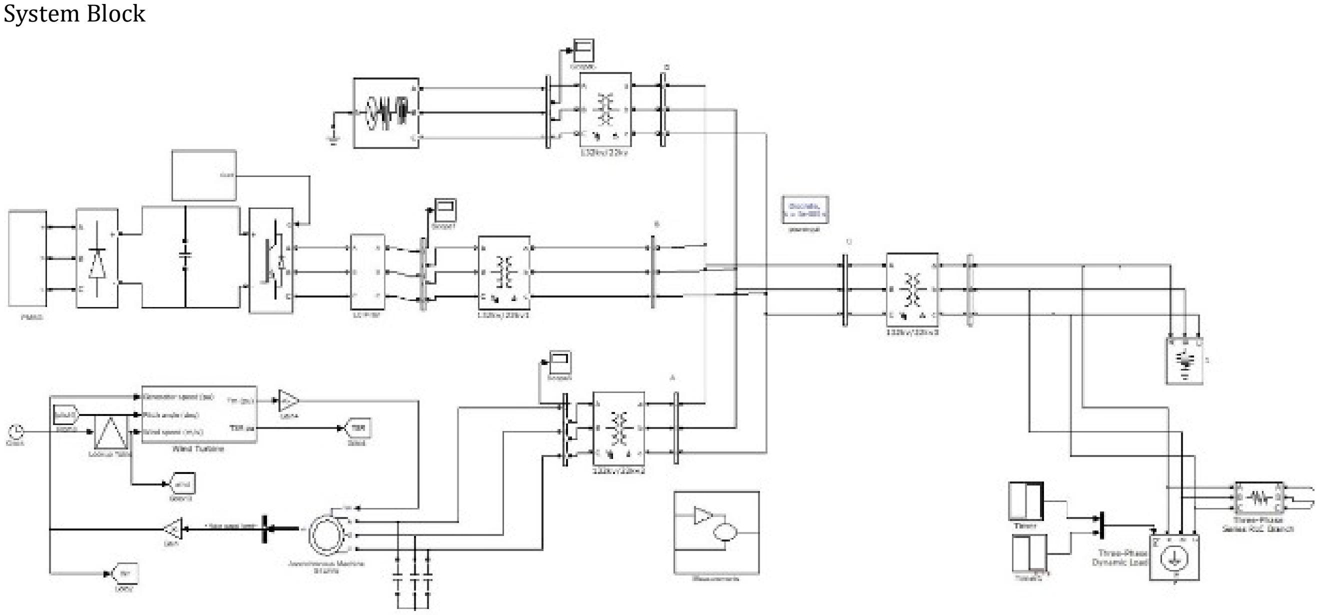

Fig.3 Matlab Simulation Diagram

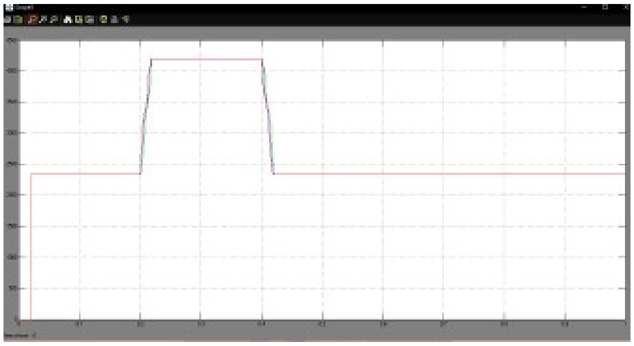

Fig.3 Waveform of Active and reactive power

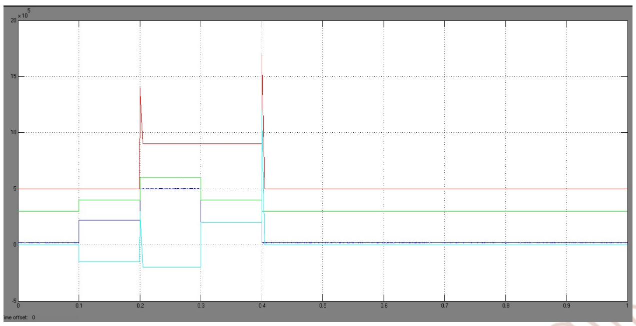

Fig.4 Waveform of Active and reactive power and output of wind power system

## V. Conclusion

This project proposes a novel design for dc based grid wind power system in a microgrid, which facilitates desired real and reactive power flow between utility and microgrid and eliminates the need for the voltage and frequency synchronization. However, the proposed control design still requires further experimental validation because measurement error due to inaccuracies of the voltage and current sensors, and modeling errors due to variation in actual system parameters such as distribution line and transformer impedances will affect the performance of the controller in practical implementation. In addition model predictive control relies on the accuracy of model establishment, hence further research on improving the controller robustness to model accuracy is required.

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