

Modeling and Performance Analysis of a Grid-Tie Photovoltaic/Wind Hybrid Power System

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ABSTRACT

This project focuses on modeling and control strategies of grid-tie photovoltaic (PV)/wind hybrid system. It investigates dynamic modeling, design and control strategy of grid-tie photovoltaic (PV)/wind hybrid power system. The hybrid power system consists of PV station and wind farm that are integrated through main AC-bus to enhance system performance. The Maximum Power Point Tracking (MPPT) technique is applied to both PV station and wind farm to extract the maximum power from hybrid power system during variation of environmental conditions. The modeling and simulation of hybrid power system have been implemented using MATLAB/Simulink software. The effectiveness of the MPPT and control strategy for the hybrid power system is evaluated during different environmental conditions. The wind farm includes the grid side converter (GSC) controller for maintaining the DC-bus voltage constant and the rotor side converter (RSC) controller for extraction the maximum power from wind turbines. Moreover, hybrid power system operates at unity power factor since injected current to the electrical grid is in phase with grid voltage. The control strategy tested in the variations of environmental conditions and the injected power from the hybrid power system.

Keywords: Grid-tie photovoltaic (PV)/wind hybrid system, Maximum Power Point tracking, etc.

I. INTRODUCTION

The permanent increase in the energy demand is considered as one of the most critical issue nowadays. Besides, as conventional power sources are limited and have adverse effects on the planet, has necessitated an imperative search for renewable energy which cause no pollution of the earth. Between these sustainable energy sources, wind and photovoltaic can be considered as the most promising technologies to produce electricity. The aim of this paper is to provide solar and wind power to the utility grid. The proposed architecture of the hybrid power system consists of Doubly Fed Induction Generator (DFIG) based wind turbine and solar PV. The control of the DFIG is made through two converter rotor side converters (RSC) and the grid side converter (GSC) to generate active and reactive power and to maintain the DC bus voltage constant. MPPT control is used to maximize the PV power and a boost converter increase the voltage which used by the inverter to feed the grid.

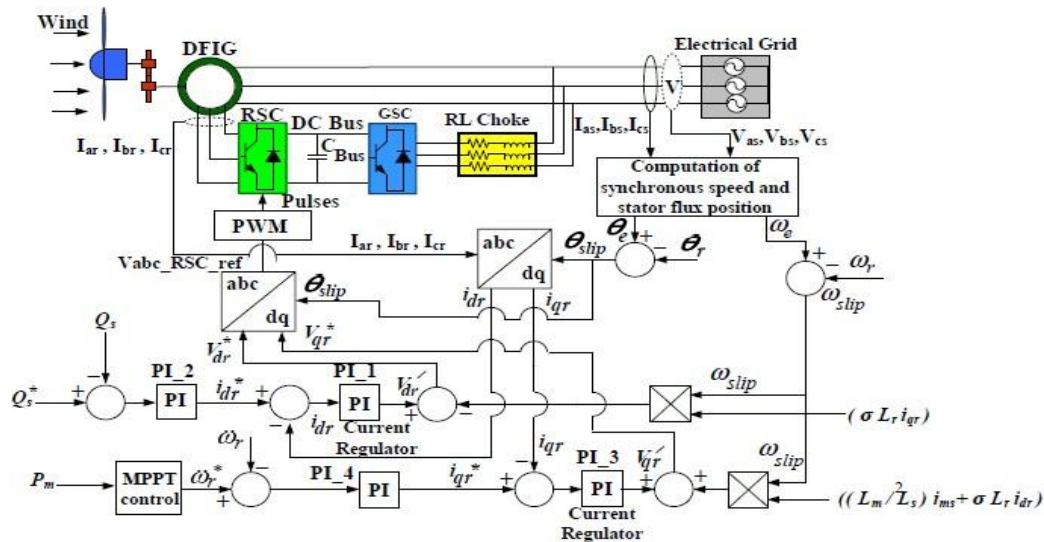
II. NEED of PROPOSED ANALYSIS

The critical issue in the entire world is to meet the permanent growth of the energy demand. Moreover, the rapid depletion and the exhaustible nature of the conventional power sources, has necessitated imperative researches for the renewable energy sources as alternative sources of energy. Among the renewable sources of energy, photovoltaic energy and wind energy have attracted great attention and can be considered as the most promising power technologies to produce electricity. The wind energy can be captured using large generators to generate great power capacity. Also, the PV energy has shown great potential as another promising power technology to generate electricity since being clean, global, and free and can be harnessed without emission of pollutants. However, both the PV energy and wind energy have their own demerits since they are intermittent in nature and immensely dependent on the environmental conditions such as the variations of solar irradiance and wind speed. Therefore, integration of these renewable energy sources as PV/wind hybrid power system can be utilized for overcoming the intermittency and generation more reliable power with higher quality to the electrical grid and rural areas.

III. DETAILED OPERATION OF THE PROPOSE WORK

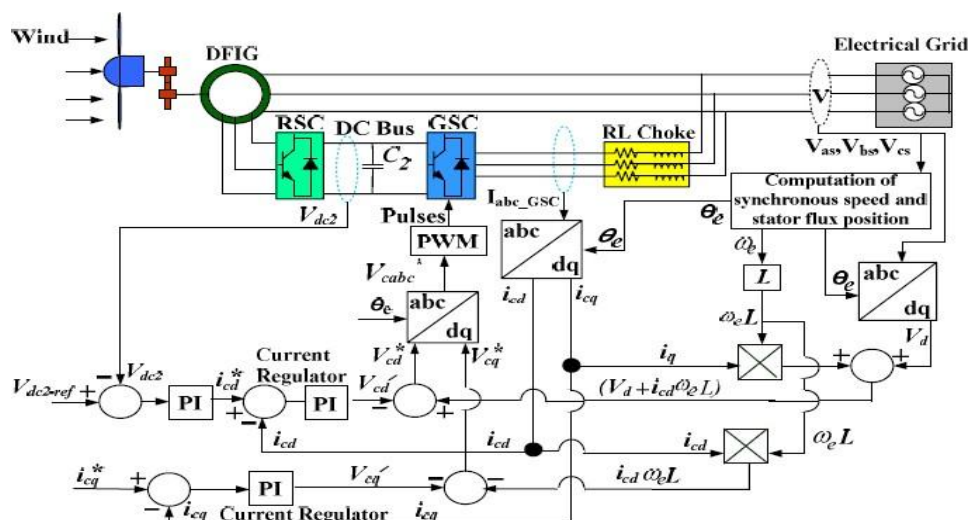
This study investigates a detailed dynamic modeling, design and control strategy of a grid-tie PV/wind hybrid power system. The hybrid power system consists of PV station of 1MW rating and a wind farm of 9 MW rating that are integrated through main AC-bus to inject the generated power and enhance the system performance. The Maximum Power Point Tracking technique is applied for both PV station and wind farm to extract the maximum power from hybrid power system during variation of the environmental conditions. The effectiveness of the Maximum Power Point Tracking technique and control strategy for the hybrid power system is evaluated during different environmental conditions such as the variations of solar irradiance and wind speed. Rotor Side Converter Controller (RSC) capture the maximum power from a wind turbine and control the injected reactive power by the DFIG to keep the stator at unity power factor. The main objective of Grid Side Converter Controller (GSC) is to maintain the DC-bus voltage constant and control the exchanged reactive power with the electrical grid. The simulation results will be proven the effectiveness of the Maximum Power Point Tracking technique in extraction the maximum power from hybrid power system during variation of the environmental conditions. Moreover, the hybrid power system will be successfully operates at unity power factor since the injected reactive power from hybrid power system is equal to zero. Furthermore, the control strategy successfully maintains the grid voltage constant regardless of the variation of environmental conditions and the injected power from the hybrid power system.

1. Rotor Side Converter Controller



The main objective of Rotor Side Converter Controller (RSC) is to capture the maximum power from a wind turbine and control the injected reactive power by the Doubly Fed Induction Generator (DFIG) to keep the stator at unity power factor. The stator flux oriented control (SFOC) strategy has been utilized to achieve the controller system.

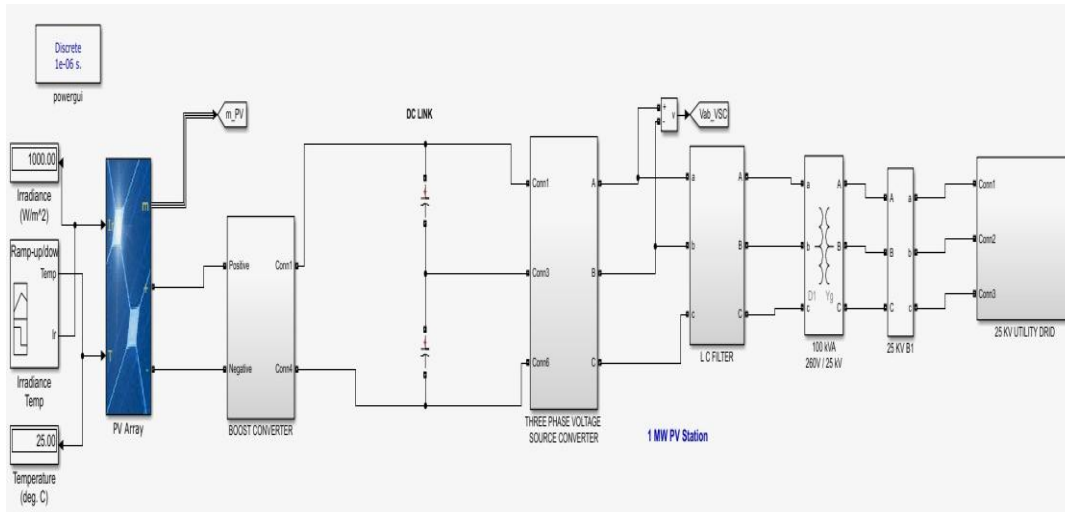
2. Grid Side Converter Controller



The main objective of Grid Side Converter Controller (GSC) is to maintain the DC-bus voltage constant and control the exchanged reactive power with the electrical grid.

IV. MATLAB SIMULATION

1. Simulink model of Photo Voltaic



2. Simulink model of Wind Farm

Fig. 1 MW PV Model

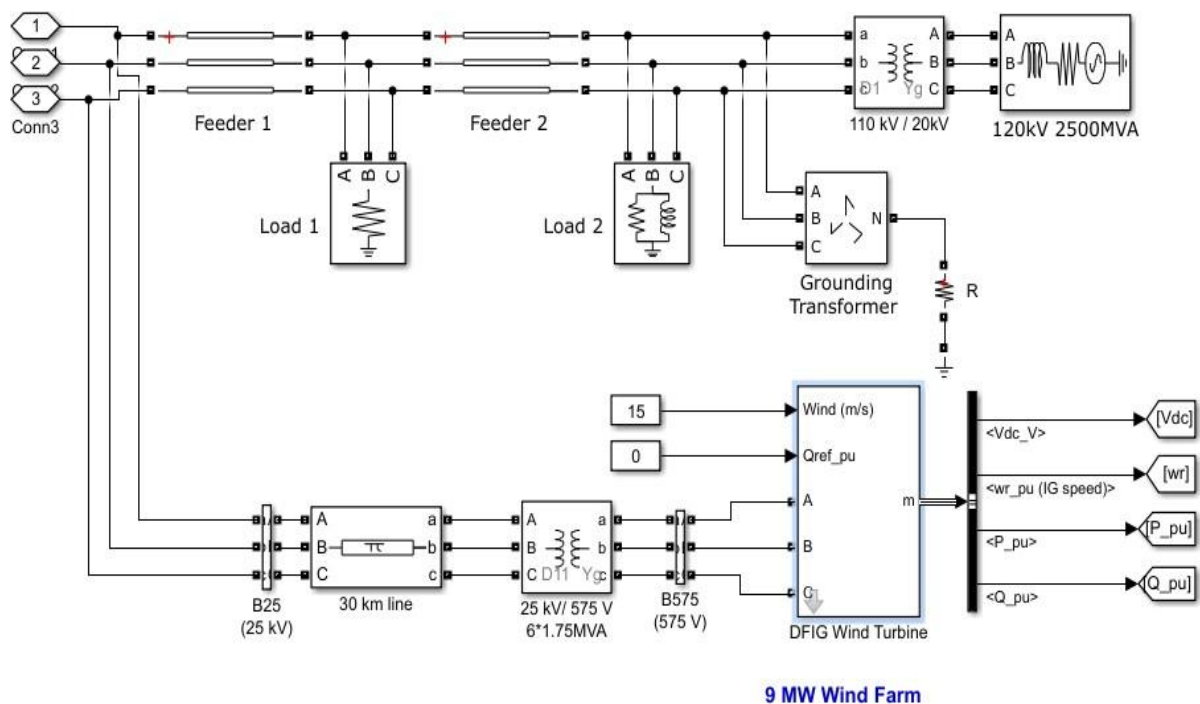
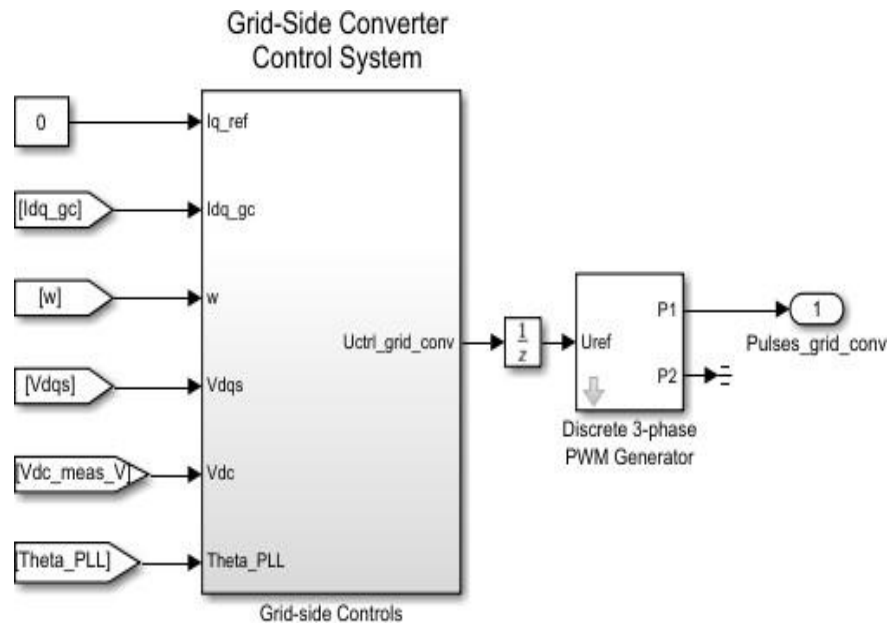


Fig. 2 MW Wind Farm



3. Simulink model of Grid-Side Converter Controller

Fig. 3 Grid-Side Converter Controller

4. Simulink model of Rotor-Side Converter Controller

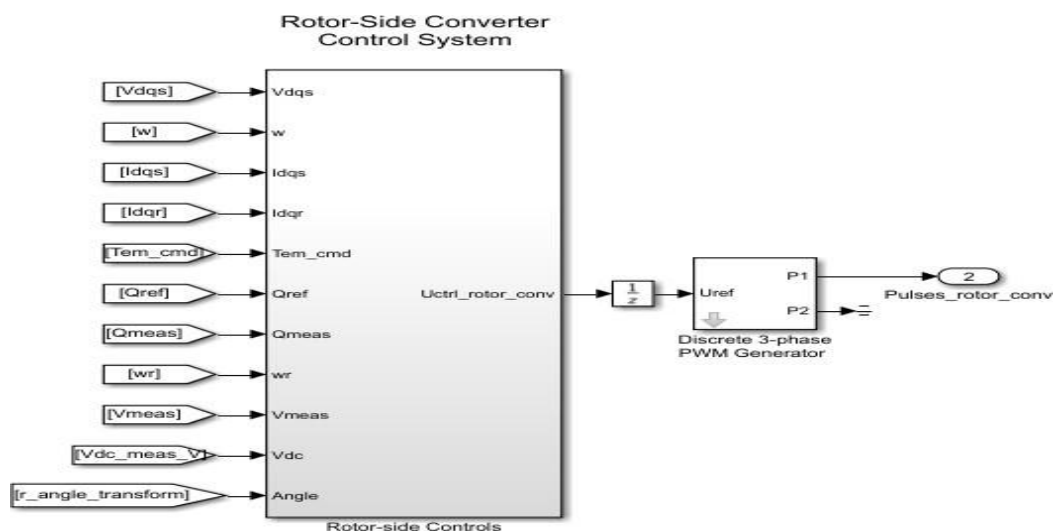
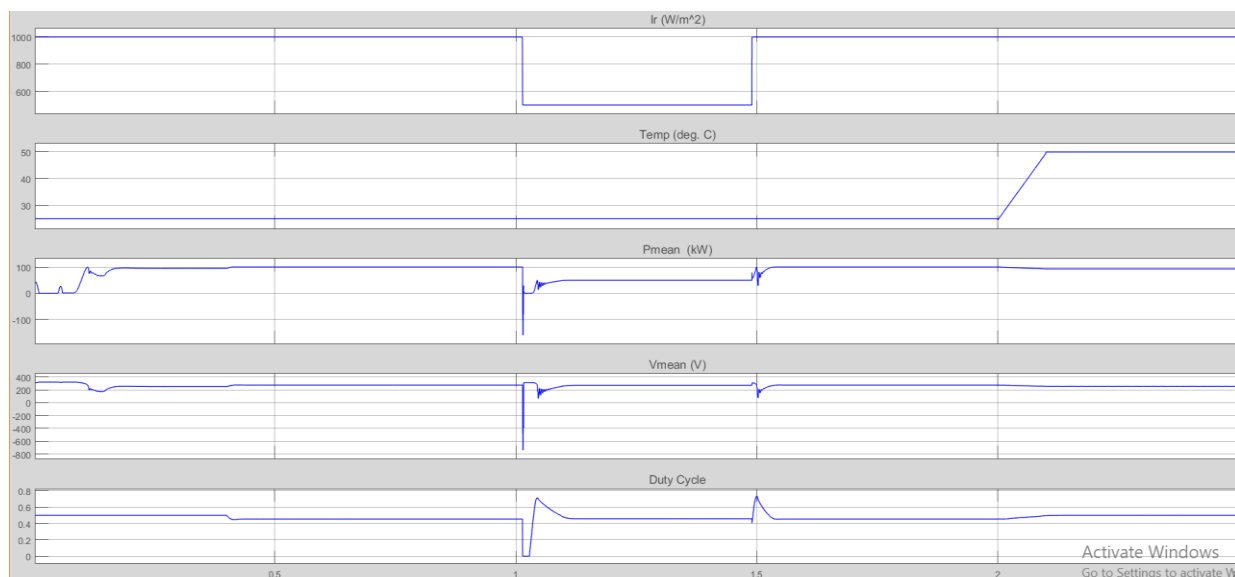


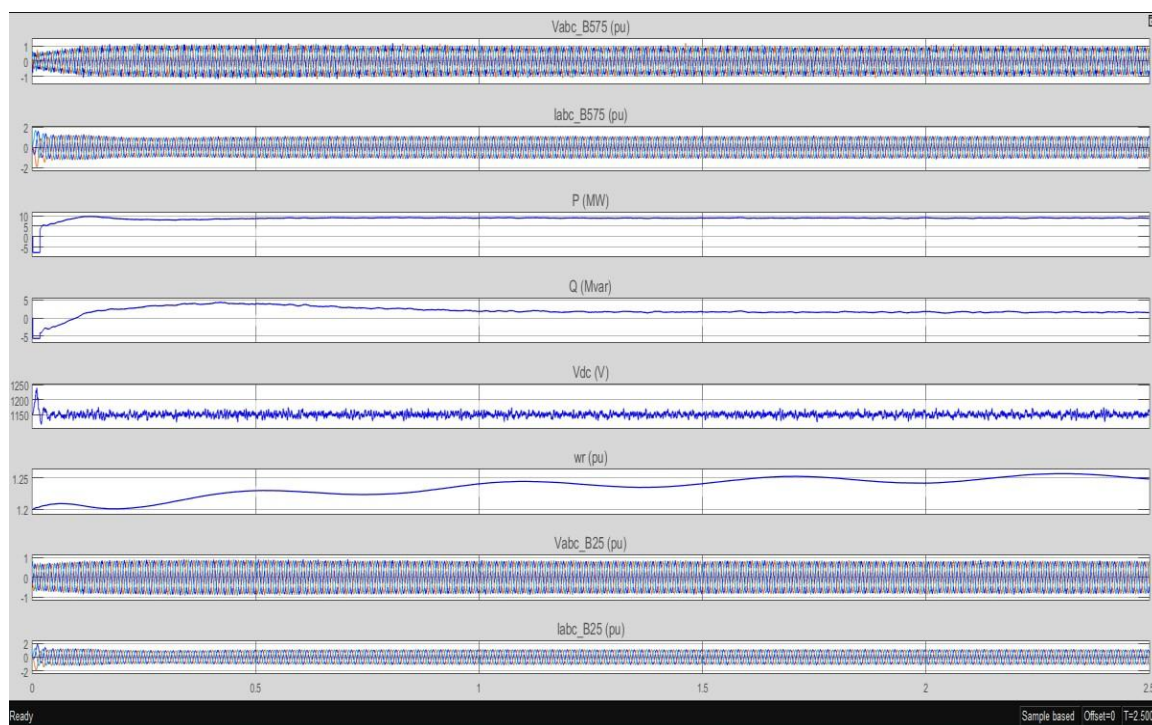
Fig.4 Rotor-Side Converter Controller

V. SIMULATION RESULTS

1. PV Station



2. Wind Farm





VI. CONCLUSION

In this project, a detailed dynamic modeling, design and control strategy of a grid-tie PV/Wind hybrid power system will be implemented. The hybrid power system consists of PV station of 1 MW rating and a wind farm of 9 MW rating that are integrated through main AC-bus to inject the generated power and enhance the system performance. The incremental conductance Maximum Power Point Tracking technique is applied for the PV station to extract the maximum power during variation of the solar irradiance. On the other hand, modified Maximum Power Point Tracking technique based on mechanical power measurement is implemented to capture the maximum power from wind farm during variation of the wind speed. The effectiveness of the Maximum Power Point Tracking techniques and control strategy for the hybrid power system is evaluated during different environmental conditions such as the variations of solar irradiance and wind speed. The simulations are carried out to validity of the Maximum Power Point Tracking techniques in extraction the maximum power from hybrid power system during variation of the environmental conditions.

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