ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

(An ISO 3297: 2007 Certified Organization)

Vol. 4, Issue 3, March 2015

A Novel d-q Control of DDPMSG in WECS for Enhanced Performance Characteristics

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ABSTRACT: PMSG driven by wind turbine to be one of the best alternatives for electric power generation which speaks for the best future energy generation. Various control strategies have been developed for obtaining the best performance characteristics. But simultaneous obtaining of there is impossible. In this paper, a novel d-q control technique is proposed on PMSG along with grid side converter, by which the performance characteristics namely the real power and reactive power are made to be enhanced. Control is implemented on the d-q voltages of the stator voltage of the PMSG. Measure will be taken to have enhanced performance characteristic .Mat Lab / simulink is used for the simulation of the so specified PMSG control techniques. A simple wind turbine system driving a PMSG without any control and with the proposed d-q control is simulated and the simulated results are shown. It has been proved that the proposed d-q control enhances the performance of the DDPMSG.

KEYWORDS: DDPMSG, WECS, d-q control, PWM power converter, abc-dq transformations

I. INTRODUCTION

Nowadays wind power is most rapidly growing renewable Energy source. Wind turbines can either operate at fixed speed or variable speed. For a fixed-speed wind turbine, the generator, normally a conventional fixed-speed induction machine is directly connected to the grid. For a variable speed Wind turbine, the generator is controlled by power electronic equipment. Moreover, due to the permanent magnet excitation of the generator, the DC excitation system can be eliminated, reducing again weight, losses, costs and maintenance requirements [1][2] The efficiency of a PMSG wind turbine was thus assessed to be higher than other variable-speed wind turbine concepts[3].

But, the performance of a PMSG depends not only on the synchronous generator but also on how it is controlled. In order to understand PMSG power generation characteristics, various techniques have been developed to investigate the behavior of a PMSG under different d-q control conditions. This can be divided into two categories: 1) transient approaches [4-10,] and 2) steady-state techniques. Transient simulation approaches are essential to study PMSG dynamic performance in a short time period.

For wind power generation, the speed of a PMSG changes as wind turbine drive power varies, and the PMSG stator terminal voltage depends on the d-q control applied to the machine side converter, making it improper to investigate PMSG characteristics using traditional approaches. On another aspect, although the d-q control regulates PMSG speed, it also changes all other parametric data of a PMSG system simultaneously, such as torque, stator real/reactive power, and the depth of PWM converter modulation, requiring an investigation for all the relevant aspects.

II. D-Q CONTROL OF DDPMSG

In modern PMSG wind turbine designs, the frequency converter is built by two self commutated PWM converters, machine- and grid-side converters, with an intermediate DC voltage link. The DC-link created by the capacitor in the middle decouples the operation of the two converters, thus allowing their design and operation to be optimized. The two back-to-back converters are controlled independently through the decoupled d-q vector control approach for

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Vol. 4, Issue 3, March 2015

modern PMSG wind turbine designs. For both converters, the direct axis current component is normally used for one control goal and the quadrature axis current component utilized for another control goal [5]. Consider fig.1 shows control of PMSG wind turbine.

The power electronic converter controller in a PMSG is divided into two parts: the machine side converter controller and the grid-side converter controller.

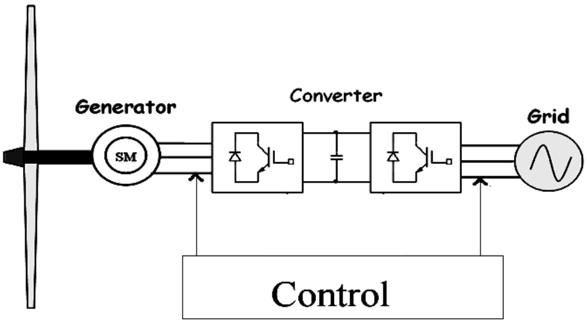

Fig: 1 Control of PMSG wind turbine

The fixed-speed wind-turbine direct driven with permanent magnet synchronous generator converts with rectifier. Here getting output waveform for the machine side controller and the input waveform for the grid side controller. To measure the voltage from the DC link capacitor to maintain the desired value. The d-q control of the power electronic converter is applied depends upon for this enhanced performance characteristics.[11]

When aligning the direct axis along the grid voltage position, the d-axis current represents the active component and the q-axis current the reactive component. The d and q components are used to regulate converter DC link voltage and reactive power, respectively. The converter d and q voltage control signals.[12]

The machine-side controller is also a two-stage controller operating in the permanent magnet flux position. A conventional constant stator voltage control strategy, in which each control loop has a cascaded structure: a fast inner current loop, controlling the stator d- and q-axis currents, combined with an outer slower loop for active power and stator voltage control, respectively. The d-q voltage control signals, the final control action applied to the converter, are obtained by comparing the stator d- and q current set points to the actual stator d- and q-currents.[13-17]

III. WIND TURBINE DESIGN

The design specification for a wind-turbine will contain a power curve and guaranteed availability. With the data from the wind resource assessment it is possible to calculate commercial viability. The aerodynamics of a horizontal-axis wind turbine is not straightforward. The air flow at the blades is not the same as the airflow far away from the turbine.. In addition the aerodynamics of a wind turbine at the rotor surface exhibit phenomena that are rarely seen in other aerodynamic fields.[18]

A wind turbine is designed to produce a maximum of power at wide spectrum of wind speeds. The wind turbines have three modes of operation.

- Below rated wind speed operation
- Around rated wind speed operation
- Above rated wind speed operation

If the rated wind speed is exceeded the power has to be limited. For a given survivable wind speed, the mass of a turbine is approximately proportional to the cube of its blade-length. Labor and maintenance costs increase only gradually with increasing turbine size, so to minimize costs, wind farm turbines are basically limited by the strength of materials, and siting requirements. Consider fig: 2 shown wind generation system.[19-21]

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(An ISO 3297: 2007 Certified Organization)

Vol. 4, Issue 3, March 2015

Typical modern wind turbines have diameters of 40 to 90 m (130-300 ft) and are rated between 500 KW and 2 MW. As of 2005 the most powerful turbine is rated at 6 MW.

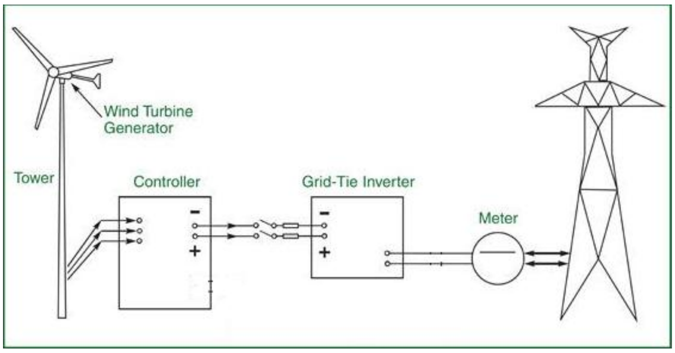

Fig: 2 wind generation system

For large, commercial size horizontal-axis wind turbines, the generator is mounted in a nacelle at the top of a tower, behind the hub of the turbine rotor. Usually the rotational speed of the wind turbine is slower than the equivalent rotation speed of the electrical network - typical rotation speeds for a wind generators are 5-20 rpm while a directly connected machine will have an electrical speed between 750-3600 rpm.

IV. SIMULINK CIRCUITS

In fig 3 is shown the simulink circuit for wind

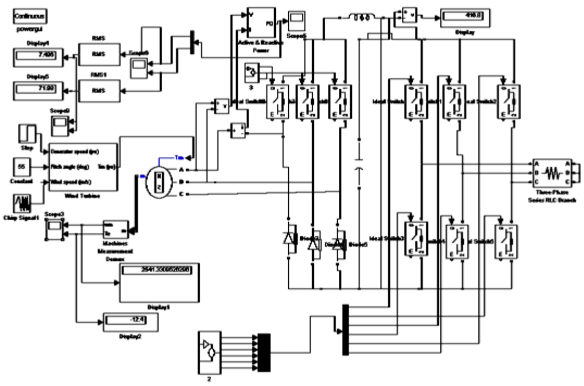

Fig: 3 Wind turbines DDPMSG without d-q control

turbine DDPMSG without control of the power electronics converter controller. The output of the wind turbine is given to PMSG. The input of the semi-converter rectifier is taken from the PMSG and its output is given to the inverter whose output is then connected to grid.

The general strategy for transformation from d-q control signal to the three-phase sinusoidal control signal in which the d and q reference current, i_{ds} and i_{qs}, are d and q output voltages from the PMSG machine-side controller. The two α and β voltages together are then used to generate the three-phase sinusoidal reference current signals, i_a, i_b, and i_c, for control of the machine-side PWM converter. The injected current is linearly proportional to the three-phase

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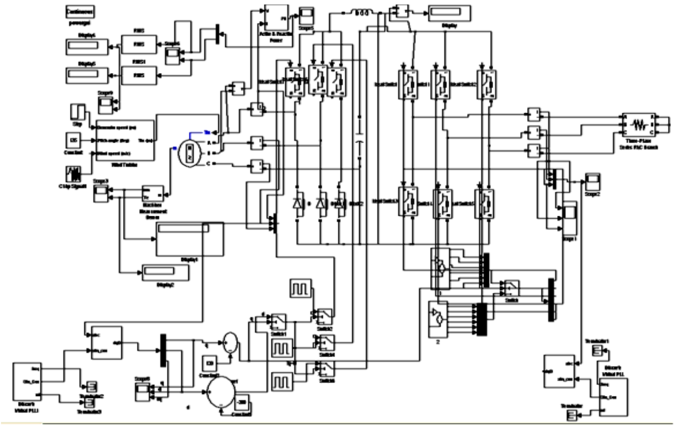

Fig: 4 Ids control of wind turbines DDPMSG

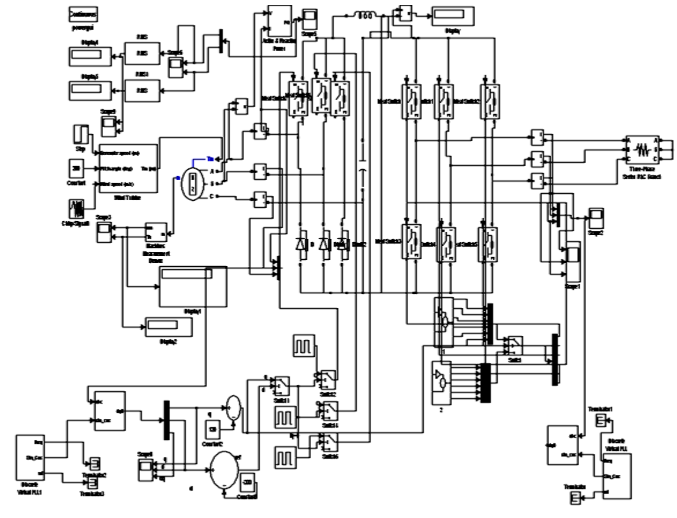

Fig: 5 Iqs control of wind turbines DDPMSG

sinusoidal control current signals in normal converter linear modulation mode. Therefore, in d-q reference frame, the direct axis component of the injected rotor current is proportional to the d reference current I_d, and the quadrature axis component is proportional to the q reference current I_{qs} .Fig. 4 represents the simulink circuit for I_{ds} control proposed to wind turbine DDPMSG . Fig. 5 represents the simulink circuit for I_{qs} control proposed to wind turbine DDPMSG.

The proposed I_{ds} and I_{qs} control method is used to enhance the power of the system.

V. WAVEFORMS AND OBSERVATION

Simulation is an effective way to investigate the operations and controls of a PMSG for wind power generation.

Figs 6 represent the waveform of torque and speed characteristics of DDPMSG without control and with control, respectively.

In this the value of torque is negative because it is generator side. In spite of d-q control given to the wind turbine system, the torque –speed characteristics remain unaltered.

Fig 7 and 8 represents variable speed characteristics with I_{ds} and I_{qs} proposed control. Different speed is given to wind turbine, in this value torque is negative because it is PMSG.

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(An ISO 3297: 2007 Certified Organization)

Vol. 4, Issue 3, March 2015

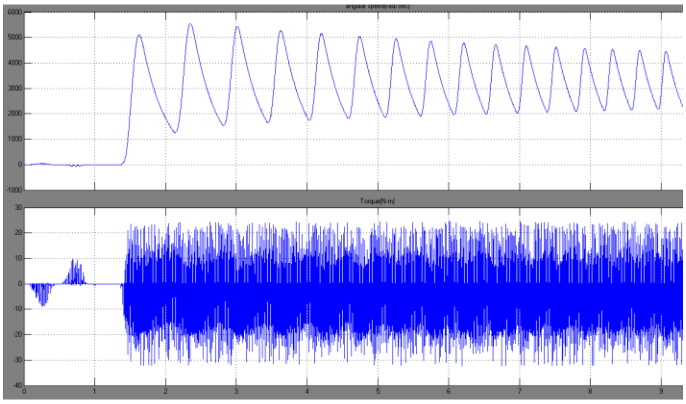

Fig: 6 Torque and Speed Characteristics of DDPMSG without Control

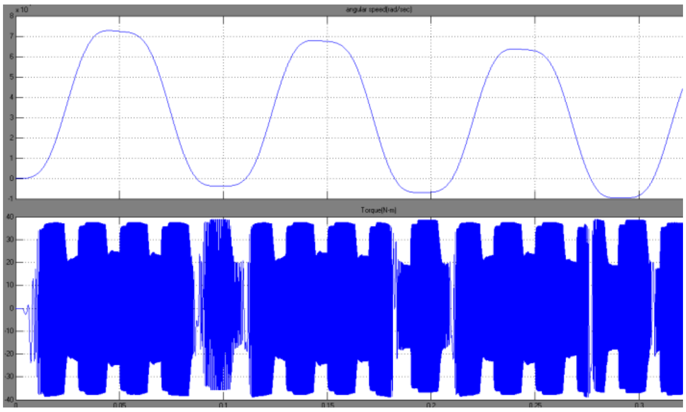

Fig: 7 Torque and Speed Characteristics for I_{ds} Control

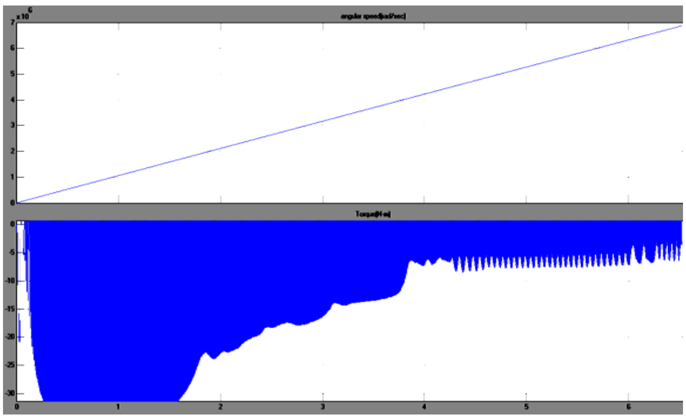

Fig: 8 Torque and Speed Characteristics for I_{qs} Control

After proposed Ids and Iqs control the value of the torque and speed characteristics are enhanced very well.

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ISSN (Online): 2278 – 8875

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Vol. 4, Issue 3, March 2015

The power generation of a PMSG includes real and reactive powers delivered to the machine-side converter through the generator stator path. However, for a PMSG, the operating speed is affected by the wind speed, and the generator terminal current depends on the d-q control applied to the machine-side converter, making PMSG real or reactive power characteristics different from a traditional Variable-speed synchronous generator.

Similarly fig 9 represents real and reactive power characteristics without proposed control.
Fig 10 and 11 represents real and reactive power characteristics of the proposed I_{ds} and I_{qs} control. From the wave form it can be observed that the reactive and real power is enhanced by using d-q control

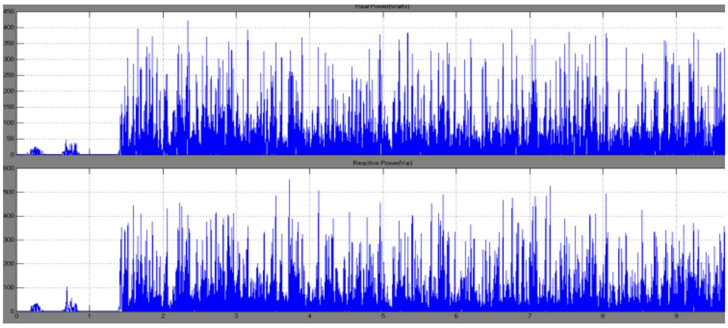

Fig: 9 Real Power and Reactive Power Characteristics without Control

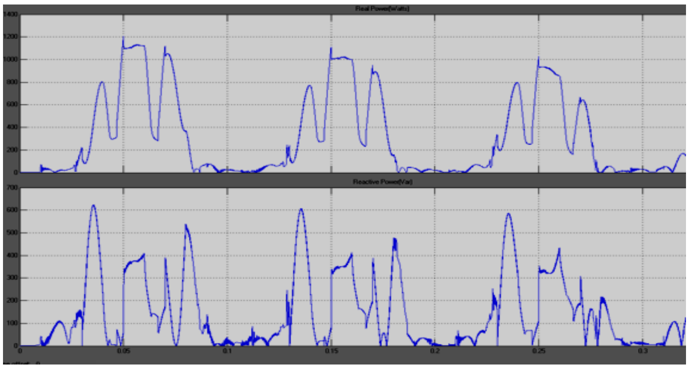

Fig: 10 Real Power and Reactive Power Characteristics for I_{ds} Control

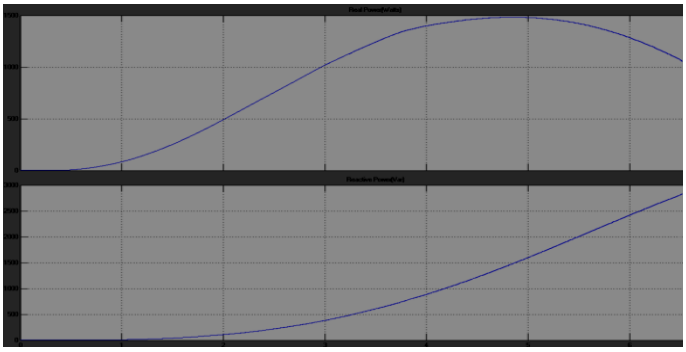

Fig: 11 Real Power and Reactive Power Characteristics for I_{qs} Control

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ISSN (Online): 2278 – 8875

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VI. CONCLUSIONS

This paper shows the performance of a direct-driven Permanent-magnet synchronous generator used in variable speed wind-energy conversion systems with Ids-Iqs control.

The efficiency of a PMSG wind turbine was thus assessed to be higher than variable-speed wind turbine. The DC excitation system can be eliminated, reducing again weight, losses, costs and maintenance requirements less.The various control strategies have been developed for obtaining these best performance characteristics. Enhanced performance characteristics of the variable speed in the wind turbine were measured successfully. It has been observed that d-q control provides a great enhancement of power and the torque speed characteristics remain unaltered. The model was simulated using Matlab/Simulink and the results are shown and compared. The simulation model built up in the paper provides corresponding technique support and analysis method for further research on direct-drive permanent magnet synchronous wind generation system.

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