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Harmonics Analysis of Distorted Grid Voltage for Doubly Fed Induction Generator

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ABSTRACT

This paper is based on harmonic analysis of DFIG for direct power control in condition of without VPI and with VPI. The dynamic performance of doubly fed induction generator is under various operating conditions like stability, grid voltage distortion as well as without distortion. In this paper direct power control (DPC) strategy is applied for doubly fed induction generator (DFIG)-based wind power generation system under distorted grid voltage and without distortion grid voltage. Harmonic component analysis of electrical grid is calculated. Harmonic Analysis under four operating conditions like VPI enabled, VPI Disabled, Transient Condition and Ideal grid voltage. In MATLAB Simulation DPC strategy is also shows an excellent disturbance rejection ability and closed-loop operation stability.

KEYWORDS: MATLAB, VPI Regulator, Direct Power Control(DPC), Harmonics

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INTRODUCTION

Slip ring induction motor plays a vital role where outsized mechanical power and switching speed are important. Speed tuning may be accomplished by slip power control but power factor complications confine the utility of this system [1]. Doubly fed induction generator (DFIG) based wind power generation system has attracted much attention and dominated the global wind energy market due to its distinct advantages such as maximum power capture during wide speed range, decoupled active/reactive power regulation, reduced mechanical stress on the mechanical train and low converter cost[2] . The Doubly-Fed Induction Generator (DFIG) is an induction generator with both stator and rotor windings. The DFIG is nowadays widely used in variable-speed wind energy applications with a static converter connected between the stator and rotor[3.] Doubly-fed induction generator (DFIG) has gained increasing popularity due to several advantages, including smaller converters rating around 30% of the generator rating, variable speed and four quadrants active and reactive power operation capabilities, lower converter cost, and power losses compared with the fixed-speed induction generators or synchronous generators with full-sized converters[4,16]

MATHEMATICAL MODELING OF DOUBLY FED INDUCTION GENERATOR

The control and operation of DFIG-based wind power system under unbalanced conditions can be significantly improved by simultaneously eliminating torque and total generated active power oscillations.

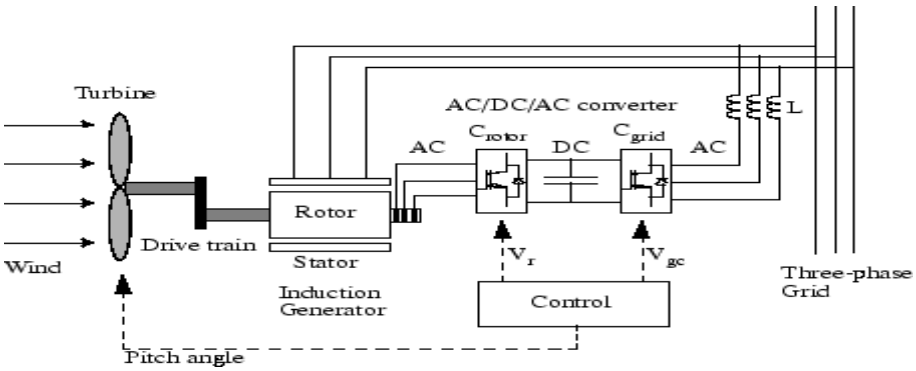

Figure:1 Block Diagram Of Proposed System

The DFIG rotor active power momentary value may be calculated as:

$$p_{ra} = u_{r\alpha} i_{r\alpha} + u_{r\beta} i_{r\beta}$$

The stator active and reactive powers as:

$$P_s + jQ = -K\sigma U_{sd}^{+} \psi_{rd}^{+} + jK\sigma U_{sd}^{+} \left(\frac{L_r}{L_m} \frac{U_{sd}}{\omega_1} + \psi_{rq}^{+} \right)$$

Harmonics Components of DFIG in mathematical expression for voltage

$$V_{ra}(t) = V_s \sum_{k}^{\infty} \frac{1}{k} \sin(k\omega t),\ \mathrm{k} = 1,5,7.....$$

Where $V_s = \frac{2}{\Pi} V_B$

FLOW CHART OF PROPOSED SYSTEM

The process of proposed solution is represented through flow chart. We need selection of doubly fed induction generator parameter for wind energy system after that which type of control technique is suitable for our proposed work so its parameter is also required to calculate if all parameters are identify effectively then we apply direct power control technique and then vector PI regulator is connected after that performance of doubly fed induction generator is checked.

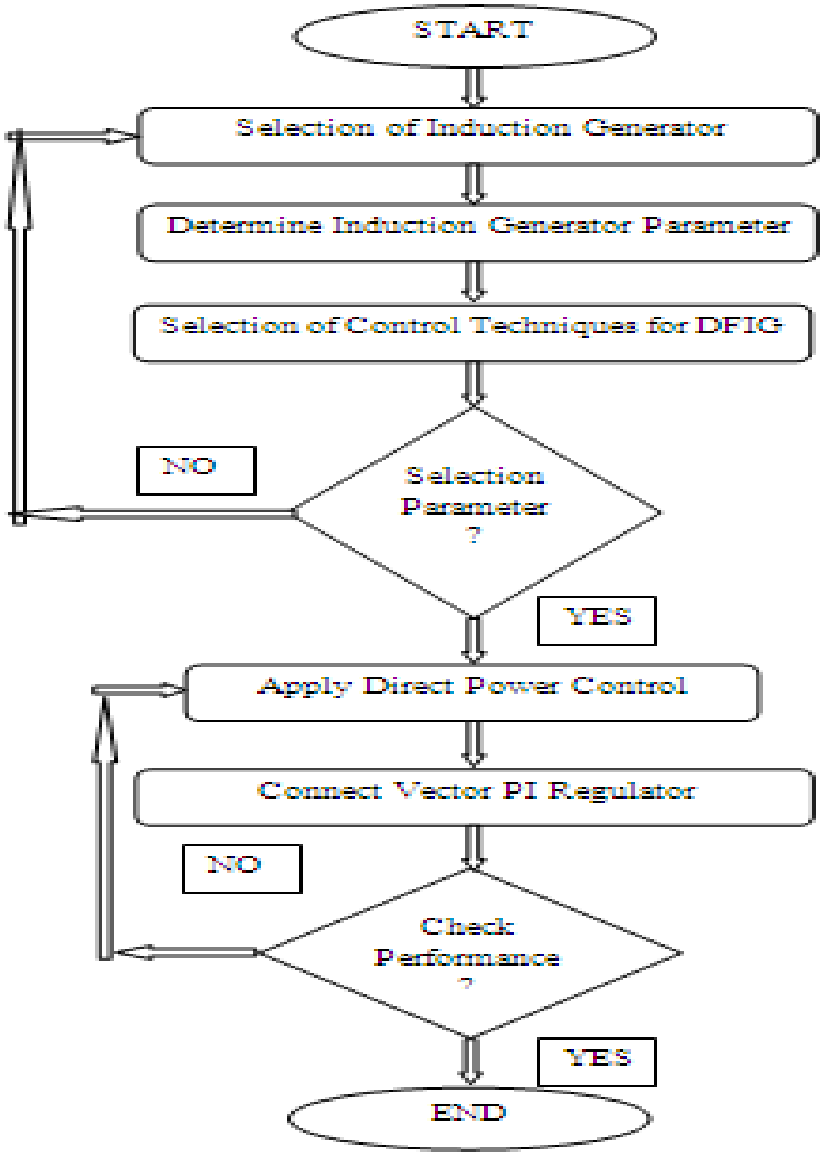

Figure:2 Flow Chart For Proposed System

SIMULATION, ANALYSIS AND RESULTS

To analyze harmonics caused by non-sinusoidal rotor injection and unbalanced stator conditions in a doubly-fed induction generator. Harmonics level has been investigated under steady state operation of the DFIG.This system consists of a doubly fed induction generator with a four-quadrant ac-to-ac converter based on IGBTs connected to the rotor winding, and the stator winding directly connects to power systems. In below figure MATLAB simulation of direct power control of DFIG using VPI shows that DFIG is connected and the VPI regulator is applied with the resonant band width ωc =15 rad/s, the resonant parameter Kpr, and Kir is chosen as 1 and 157 based on the rule of pole-zero cancellation.

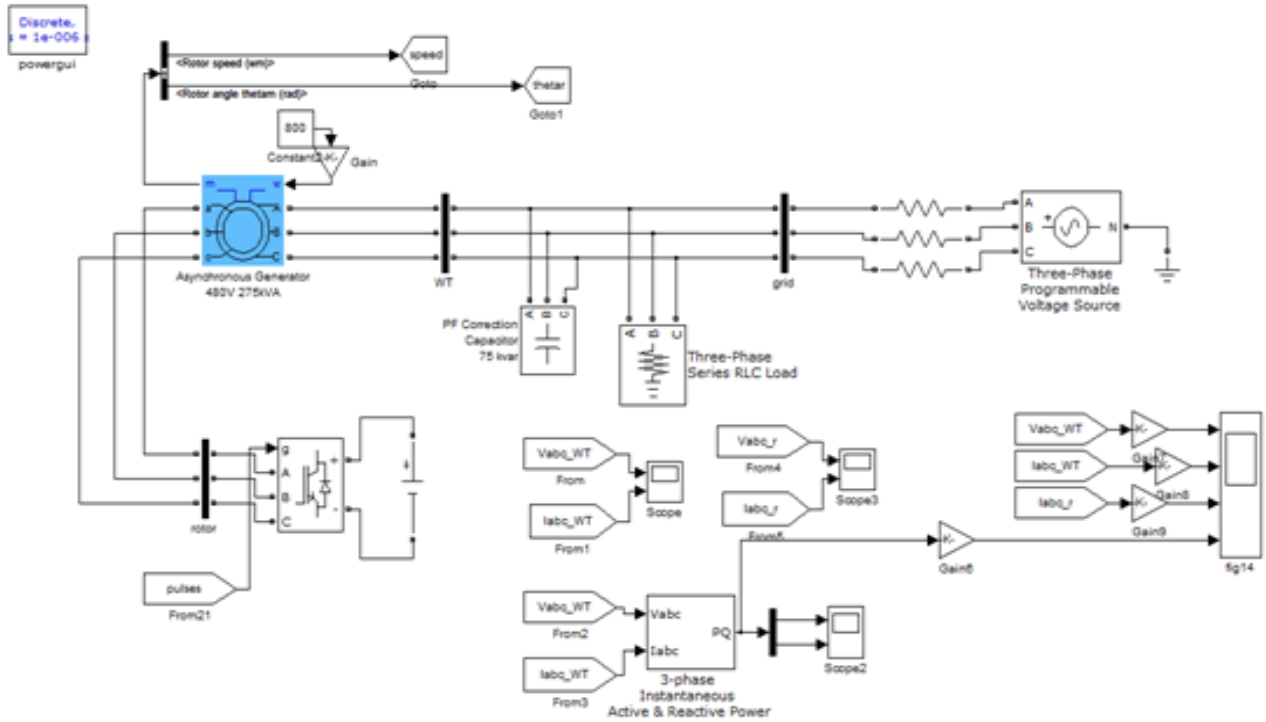

Figure:3 MATLAB Simulation Of Direct Power Control Of DFIG Using VPI

In waveform U_{sabc},I_{sabc} , $I_{rabc}$and W, VAR is shows these simulation results without VPI regulator. The direct control of the active and reactive power of the DFIG by the stator current provides global asymptotic regulation in presence of the stator current reference variation.

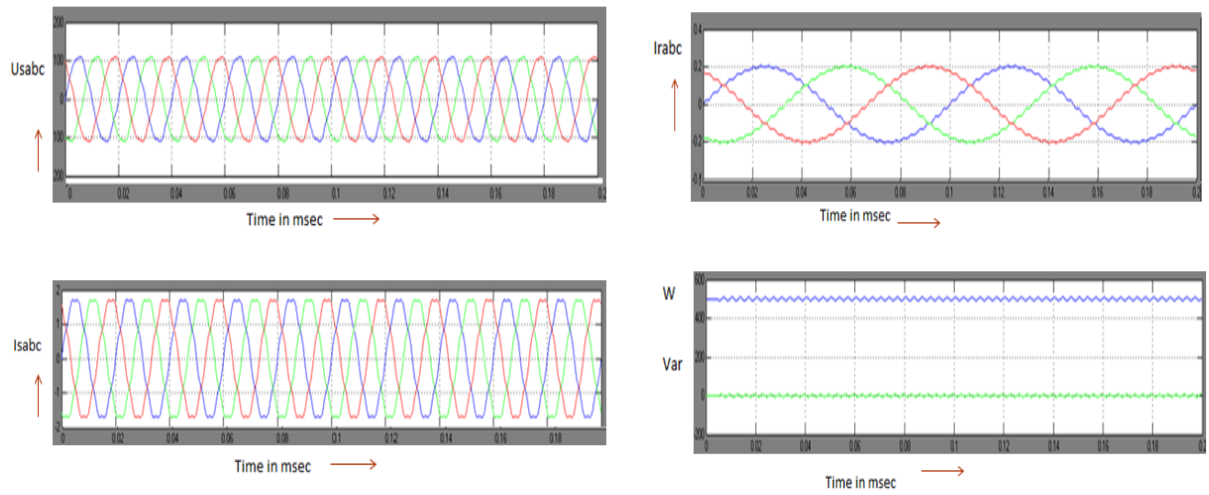

Figure:4 SimulationResults OfDPC Without VPI Regulator

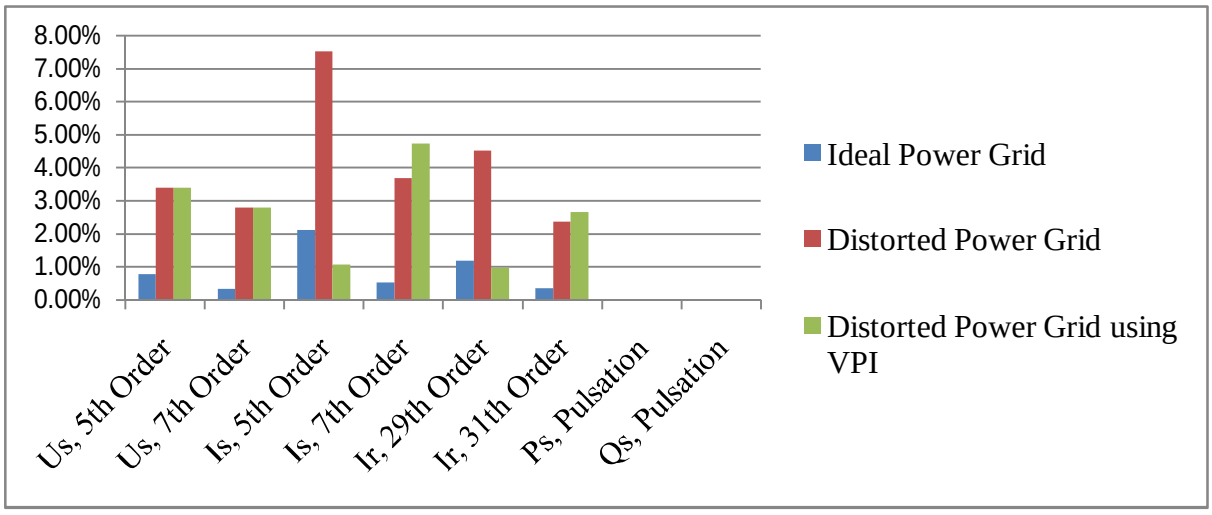

Figure:5 harmonic analysis

It would inevitably result in the non-sinusoidal air gap magnetic field and the corresponding stator and rotor harmonic current. Such no sinusoidal components would always exist during the experiment, and it would help to better understand the proposed DPC strategy if these no-sinusoidal components are considered as the background harmonics.

Table: 1 result analysis summary

Sr. No.	Parameter	VPI disabled	VPI Enabled	Transient Performance	Ideal grid Voltage
1.	U_{Sabc}	110	100	100	100
2.	I_{Sabc}	1.8	1.5	1.5	1.5
3.	I_{rabc}	2	2	3	2
4.	W	500	500	500	500
5.	VAR	1	1	0	0

CONCLUSION

A new configuration for power control system of the doubly-fed wound rotor induction generator is presented. The active and reactive power of generator can be controlled independently and stably. A VPI-based DPC strategy for a wind turbine driven DFIG system under the harmonically distorted grid voltage, ideal grid voltage and transient performance which suppress the power pulsation component, it is implement with smooth active and reactive power output of DFIG under the harmonic voltage. There are four configurations are presented for calculation stator voltage and current as well as rotor current, active power and reactive power of DFIG.

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