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Dynamic Modeling of Seven-Phase Induction Generator

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Abstract

High power applications require Multi-phase induction machines, considered viable contenders to the three phase machines operating as generator. An endeavor is made to develop a dynamic model of seven-phase induction generator and explore the generator functionality at no-load and different loading conditions. This paper analyzes the performance of seven-phase induction machine for various operating condition. The simulation model is developed using Matlab/Simulink. The seven phase generated voltage, current and torque are presented. The generator functionality is examined for different speeds and varying excitation capacitances.

Keywords: *seven phase;Induction Generator,d-q model,self-excitation;multiphase*

1. Introduction

Nowadays, the ever growing energy demand and the environmental concern have motivated researchers to explore the renewable energy sources to meet the power demand where the power electronic converters help in grid integration. The advantage of multiphase machines presents itself as a potential viable solution for high power applications. [1]- [2]. Wind, solar, biomass, geothermal, micro/mini hydro are various renewable energy sources studied. Amongst all electric power generation using wind energy is significant as they are found abundant in nature and their utilization is adequate to achieve imminent energy requirement. [4]- [5]. The ruggedness and maintenance free operation of induction generators combines the higher phase number to yield a better operating generator suitable for high power applications like high power compressors, fuel/hybrid electric vehicles, electric power steering and electric ship propulsion etc [3]. The main advantage of multiphase generator is power output is increased in the same frame with reduced per phase current without need to increase the per phase voltage, improved fault tolerance, high reliability[1],[2] and [12].Several works reported in [6]-[8] analyses dynamic and

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steady state model of the six phases self-excited induction generator. The different excitation capacitance and loading configurations are discussed in detail [9]-[11]. This paper yearns at developing a malleable model of seven phase induction generator (7ϕIG) in self excited mode. The performance of 7ϕIG is analysed under different operating conditions using the analytical model developed using Matlab/simulink. The detailed investigation of the results obtained through simulation is carried out and presented in the following sections.

2. System Description

The general block diagram of standalone 7ϕIG system considered for analysis is shown in Fig.1. The prime mover which may be a hyrdo/wind turbine drives the 7ϕIG through the gearbox. The seven phase AC output of the generator feeds power to the load through power electronic interface. A seven phase capacitor bank is used for self-excitation of the generator.

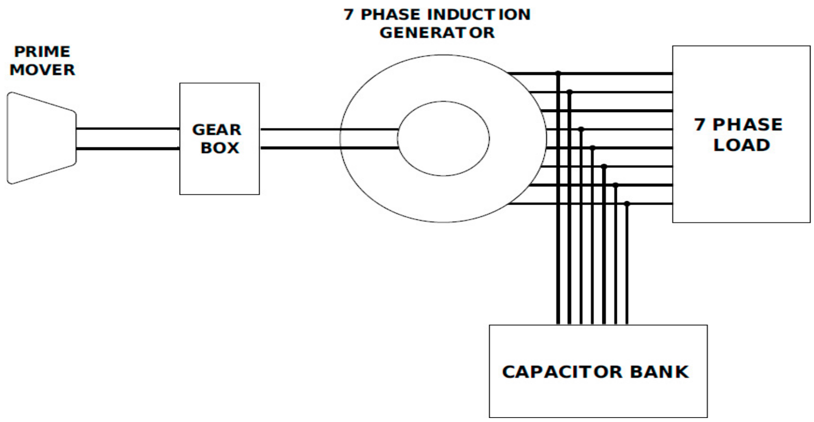

Fig.1 Standalone Seven phase Induction Generator

3. Modeling of seven phase induction generator

A 7ϕIG has seven stator windings sinusoidally distributed with phase displacement of 51.4º (360º/7) and the rotor is short circuited for squirrel cage induction machine. The 7ϕ induction machine operating as generator is represented as a two phase equivalent circuit. The d_s -q_s represents stator direct and quadrature axes and d_r -q_r represents rotor direct and quadrature axes. The transformation of seven phase stationary reference frame variables to two phase stationary reference frame is given by equation (1).

$$\begin{bmatrix} V_{q_s} \\ V_{d_s} \\ V_{x_s} \\ V_{y_s} \\ . \\ V_{o_s} \end{bmatrix} = \begin{bmatrix} 1 & \cos\alpha & \cos 2\alpha & \cos 3\alpha & . & \cos n\alpha \\ 0 & \sin\alpha & \sin 2\alpha & \sin 3\alpha & . & \sin n\alpha \\ 1 & \cos 2\alpha & \cos 4\alpha & \cos 6\alpha & . & \cos 2n\alpha \\ 0 & \sin 2\alpha & \sin 4\alpha & \sin 6\alpha & . & \sin 2n\alpha \cdot \\ . & . & . & . & . & . \\ \frac{1}{\sqrt{2}} & \frac{1}{\sqrt{2}} & \frac{1}{\sqrt{2}} & \frac{1}{\sqrt{2}} & . & \frac{1}{\sqrt{2}} \end{bmatrix} X \begin{bmatrix} V_a \\ V_b \\ V_c \\ V_d \\ . \\ V_n \end{bmatrix} \tag{1}$$

Where α=2π/n; n-no of phases