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Analysis, Voltage Control and Experiments on a Self Excited Induction Generator

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Abstract. In this paper dynamic analysis, closed loop voltage control and experiments on a self excited induction generator are presented. Electromagnetic torque, active power and reactive power are controlled under dynamic conditions of varied load, excitation capacitance and shaft speed, A closed loop voltage control scheme using a PWM Voltage Source Converter (VSC), dc link capacitor and a P-I voltage controller is proposed and implemented. This scheme generates constant voltage and variable frequency using the converter which also acts as a reactive power compensator. The frequency of stator voltage and current is varied by changing the error proportional gain making it attractive for wind energy conversion system. The simulation is done using MATLAB environment and the experimental results are also presented in this paper.

Key words

Self excited induction generator (SEIG), sinusoidal pulse width modulation (SPWM), reactive power compensation, voltage control, wind energy conversion system.

1. Introduction

Windy areas, waterfalls, reservoirs, high tide locations are extremely helpful for generating clean and economical electrical energy by proper harnessing mechanism. Throughout the globe in last three to four decades generation of electricity out of these renewable sources has created wide interest. Growing interest in water management and sustainable environment toward a sustainable world has awaken new sources of hydro energy. Among these are the run-of-river plants to produce electricity using induction generators. The induction generator self excitation phenomena is reviewed in [1]. The brushless construction, robustness, low maintenance requirements, absence of DC power supply for field excitation, small size, self protection against short circuits are the advantages of asynchronous generator over the synchronous and DC generators. The relatively poor voltage and frequency regulation and low power factor are its weaknesses [1]. The frequency and magnitude of voltage generated by the self excited induction generator (SEIG) is completely governed by the rotor speed, the excitation and the load [2]. There exist minimum and maximum capacitance for the self excitation to occur i.e., voltage build up at a particular speed. Also it requires a minimum cut in speed for successful voltage build up and it has a maximum speed limit considering mechanical safety for a fixed excitation capacitance [3-4]. The effect of dynamic mutual inductance on voltage build up process of SEIG is discussed in [5]. The application of power semiconductor devices, controlled converter circuits, and control algorithms has resulted in suitable regulating schemes for self excited variable speed squirrel cage generators. From the electricity company standpoint, accurate controls of voltage and frequency can limit the electrical and mechanical stresses in the power system and deliver good quality energy. Already many circuits are proposed to control the output voltage and/or frequency [6,7,8]. Dynamic performance of SEIG feeding different static loads is discussed in [9]. Constant voltage operation using optimization tools is discussed in [10]. The above papers did not mention the effect of speed, excitation capacitance, mutual inductance on dynamic power variations and frequency of power exchange and line voltage. This paper exploits the possible ways to generate electrical power by analyzing the machine at loaded and varied speed conditions to extract the information regarding dynamic active power, reactive power and torque variations. The viability of a constant voltage and variable frequency generation scheme is analyzed. Experimental results are presented. As wind speed is statistical in nature, this scheme could be extended to a variable speed, constant voltage and variable frequency wind energy conversion system.

2. Dynamic Analysis of SEIG

A three phase induction machine can operate as a SEIG if a suitable capacitor bank is connected across its terminals and rotor speed is sufficient to have a negative slip when driven by a prime mover. Capacitor banks provides the necessary magnetizing current to start the voltage build up process which is determined by feeding the machine as an induction motor without load and measuring the current as a function of the terminal voltage variation. A complete dynamic equation of SEIG involving an RL load in stationary reference