MODELING AND TRANSIENT ANALYSIS OF SELF EXCITED SHORT SHUNT INDUCTION GENERATOR

By

Heba Mahmoud Sofy Elsayed

A thesis submitted to the
Faculty of Engineering at Cairo University
In Partial Fulfillment of the Requirements for
The Degree of MASTER OF SCIENCE

In

Electrical Power and Machines Engineering

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Approved by the Examining committee

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Abstract

Energy demand of the world is increasing year by year. With the increasing demand of energy, besides of the exploitation of the traditional sources, new energy sources are searched and used throughout the world depending upon their availability and their relative benefits. Within the new energy sources wind energy can play a significant role in solving the world energy problem. Wind electrical generation systems are the most cost-competitive of all the environmentally clean and safe renewable energy sources in the world. They are also competitive with fossil fuel generated power and much cheaper than nuclear power.

An induction machine (IM) can be operated as a stand-alone generator. Capacitive self-excitation of IM has been known for over 80 years. Self-excitation of induction generator (IG) is initiated by means of the residual magnetism existing in the core of the machine. These types of generators are then called as self-excited induction generators (SEIG). In the wind power applications, most of the generators are induction generators.

Induction generators are being considered as an alternative choice to the well developed synchronous generators because of their relative advantageous features over conventional synchronous generators. These features are, brush less, rugged construction, low cost, low maintenance and operational simplicity, good dynamic response, and capability to generate power at variable speeds. The later feature facilitates the induction generator operation in stand-alone (isolated mode) to supply remote areas where extension of grid is not economically viable.

The main drawback of an induction generator is its reactive power demand for excitation. Therefore, capacitors should be connected across the generator terminals. Induction generators have poor voltage and frequency regulations under varying load and wind speeds. Also the induction generator

demagnetizes and stops generating voltage either when the wind speed falls below or the load rises beyond certain values.

By using series capacitors in addition to shunt capacitors the so called Self-excited Short shunt Induction Generator (SESSIG) is considered one of promising solutions of the SEIG's problems.

The main objective of this thesis is studying the transient performance of SESSIG for balanced conditions. So a variable speed SESSIG is modeled by Matlab program with variable shunt and series capacitances and variable loads. For this purpose, a general mathematical model of the system in a stationary reference frame has been derived. Based on this model, steady-state and transient characteristics of the SESSIG are studied. The variable shunt and series capacitances aim to ensure a constant voltage-constant frequency operation under different operating conditions. The developed computer program facilitates prediction of performance under the given speed, capacitors and load conditions, which helps in estimating system parameter such as capacitors for a given prime mover and load pattern in the field. The study proved that, the SESSIG can be used as a constant voltage-constant frequency supply with controlled shunt and series capacitances under different operating conditions such as prime mover speed, load and load power factor.