ANALYSIS AND INVESTIGATION OF A PROPOSED CONNECTION AND CAPACITANCES CALCULATION FOR THE TWO WINDINGS SINGLE PHASE SELF-EXCITED INDUCTION GENERATOR FOR OPERATING AT CONSTANT VOLTAGE AND FREQUENCY

By

Eng. Heba Mahmoud Sofy Elsayed

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

In

Electrical Power and Machines Engineering

FACULTY OF ENGINEERING, FAYOUM UNIVERSITY

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ABSTRACT

In remote areas, rural communities are in need for single phase power supply to meet their energy requirements. The single phase self-excited induction generator (SEIG) is the most suitable and economical option for such power application. Where the rugged cage rotor construction, lower unit cost, absence of separate DC source, stable operation and self-protection against faults are main reasons for the preference of SEIG over conventional synchronous and DC generating units. However, they suffer from poor voltage regulation as they are incapable of generating reactive power rather they consume it.

The single phase SEIG (SPSEIG) can be operated in two different classes which are the single winding SPSEIG (SWSPSEIG) and the two windings SPSEIG (TWSPSEIG). The single phase supply can also be delivered by three phase induction machines operated as SPSEIG. The main objectives for the different configurations are always to deliver the power at constant voltage (improved voltage regulation) and constant frequency. To maintain the voltage and frequency constant, the capacitors are needed to vary with the prime-mover speed variation.

This study suggests a new configuration for the TWSPSEIG providing the main objectives of constant voltage and frequency in addition to the merits of having smaller size of capacitors and less voltage stress on the machine windings. To keep the voltage and frequency of the proposed configuration, new analysis method is introduced to calculate the capacitors in steady state. The performance equations at steady state conditions are obtained by applying loop impedance method based on the double revolving field theory.

The proposed calculation method developed is then applied both to the traditional configuration known in literature and to the proposed configuration. Under constrains that the load voltage and frequency are constant, the steady state model outputs are the values of the excitation capacitor, the compensation capacitor and the prime mover speed. The variable capacitances aim to ensure a constant voltage-constant frequency operation under different operating conditions. The range of capacitors variations with variable prime mover speed are calculated at different load conditions. Also it can be concluded that the speed limits increases as the load power factor increases. The calculated capacitors for the proposed configuration show advantage of being smaller in size compared to that of the traditional configuration.

For the purpose of dynamic analysis, a general mathematical model in a stationary reference frame for both the traditional and the proposed configuration, incorporating its nonlinearity behavior and different load conditions, have been derived. The models are developed using Matlab programs with the ability to vary the speed, capacitances and loads. The calculated capacitors and the speed are obtained from the steady state programs are then used for the dynamic programs which confirmed the steady state results for the terminal voltage and frequency. From the steady state results, it is observed that the compensation capacitance increases and the excitation capacitance decreases as the speed increases in each case of load condition for both configurations. The dynamic

results for the two configurations shows that the speed decreases as the load current decreases at constant power factor.

The comparative study between the two configurations at same load conditions, illustrates the advantages of the new connection over the traditional connection such as low values of the required capacitors, low values of the main and auxiliary windings voltages and low values of the main winding current while the main disadvantage of the new connection is its low efficiency because it requires higher speed and higher auxiliary winding current.

In conclusion, the dynamic behavior of the TWSPSEIG at different operating conditions proves the capabilities of the proposed configuration and calculations method to maintain both the load voltage and frequency are constants with controlled of capacitances.