STEADY STATE ANALYSIS OF A GENERALIZED IMPEDANCE CONTROLLER (GIC) BASED BRUSHLESS GENERATOR

by

DIPANKAR SARKAR

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CERTIFICATE

*This is to certify that the dissertation entitled "**STEADY STATE ANALYSIS OF A GENERALIZED IMPEDANCE CONTROLLER (GIC) BASED BRUSHLESS GENERATOR**" submitted by Dipankar Sarkar (1998REE007) in partial fulfillment for the award of the degree of Doctorate of Philosophy in Power Electronics, Electrical Machines and Drives is a bonafied record of the work carried out by him under my supervision.*

The matter embodied in this dissertation, to the best of my knowledge, has not been submitted for the award of any degree or diploma elsewhere.

Date:

(Prof. J.K.Chatterjee)
Head, Department of Electrical Engineering
Indian Institute of Technology, Delhi
New Delhi-110016

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Dipankar Sarkar.

Dipankar Sarkar

ABSTRACT

Small-distributed generation (DG) systems, typically of 100 kW rating, have been gaining popularity in recent years to supply power to remote, isolated rural communities due to the cost and complexity of grid systems with heavy transmission losses and reduced reliability. DG systems have higher operating efficiency and lower emission levels compel one to seek autonomous power generation. Depletion of fossil fuels has turned the attention on DG systems to be powered by attractive renewable energy sources such as wind, small hydro and biomass etc., and can be used to share peak generation during peak load. A cluster of paralleled DG systems and loads within a certain local area can form a micro-grid. A micro-grid has larger power capacity and better-integrated control capability to fulfill power quality requirements and system reliability in addition to all the inherited advantages of a single DG system. Since they are all to be located in isolated regions the DG technology must be simple, rugged and easy to operate and maintain. Self-Excited Induction Generator (SEIG) has shown advantage for such applications. Such three-phase generators would often feed unbalanced loads due to very nature of distributed load arrangement dictated by the location of the loads.

For proper operation of the micro-grid wind and hydro turbine driven SEIG need to have suitable fast acting real time controllers to implement high performance power flow control and voltage regulation algorithm to satisfy proper power quality at the consumer end. The control algorithm should have communication link between paralleled DG systems, which can be located far apart. Under varying source and load conditions active and reactive power distribution in the micro grid have to be rapidly altered to provide voltage and frequency at the grid bus. Static compensator

(STATCOM) as GIC has been used to meet rapid demands of active and reactive power in the micro-grid.

Keeping in view of the need of a controller that can control both the voltage and the frequency of the SEIG, the Generalized Impedance Controller appears to be the most suitable for the following reasons:

- Smooth active and reactive power control capability as the controller can source and sink both active and reactive power.
- Wider control range for active power as compared to the other existing techniques.
- Simple configuration, as it needs fewer energy storage elements.
- Low cost and weight.

The past effort for voltage and frequency control has been around independent active and reactive power control. In the present work an attempt has been made to have a single unit based integrated active and reactive power control, which reduces the component cost and can also improve the reliability of the system. In the present work, an ingenious method of active and reactive power control, which is termed as "Generalized Impedance Controller" (GIC) has been dealt with.

In this work an effort has been made to show the capability of the proposed Generalized Impedance Controller to solve the problems relating to the fluctuation in voltage and frequency of an isolated ac system bus. The self-excited induction generator having its independent grid is an example of such system.

In almost all the earlier reported work, the effects of unregulated prime mover on the SEIG performance; for example, a SEIG with hydraulic turbine with constant water head has been neglected. Only recently some observation on this aspect has been made. However, no work has been reported on the behavior of an impedance controller as an active / reactive compensator and its application as an excitation controller when connected to a stand-alone SEIG with regulated and unregulated prime mover. The following issues emerge from the above discussion:

1. The suitability of the Generalized Impedance Controller for controlling voltage of a stand-alone SEIG with regulated and unregulated mover has to be properly explored.
2. Detailed investigation on the operation of the aforesaid impedance controller has to be taken up and its power handling capability has to be estimated under steady state and transient conditions to make use of the full potential of the compensator for stand-alone SEIG operation and control.
3. As an initial study, integrated operation of the SEIG and the proposed aforesaid impedance controller under steady state condition has to be taken up to assess the voltage controlling capability of the stand-alone generating system.

Contents