AIN SHAMS UNIVERSITY

FACULTY OF ENGINEERING

Electrical Power and Machines Engineering

Performance enhancing of grid-connected DC microgrids

A Thesis submitted in partial fulfillment of the requirements of the degree of

Master of Science in Electrical Engineering

(Electrical Power and Machines Engineering)

by

Walid Ali Mohamed Ahmed Hatahet

Bachelor of Science in Electrical Engineering

(Electrical Power and Machines Engineering)

Faculty of Engineering, Ain Shams University, 2016

Supervised By

Prof.Dr. Mostafa Ibrahim Mohamed Marei

Dr. Mohamed Mokhtar

Cairo - (2020)

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Examiners' Committee

Name and Affiliation	**Signature**
Prof. Ayman Samy Abdel-Khalik	……………….
Electrical department, Alexandria University	
Prof. Ahmed A. El-Sattar A. El-Fattah Montaser	……………….
Electrical Power and Machines, Ain Shams University	
Prof. Mostafa Ibrahim Mohamed Marei	……………….
Electrical Power and Machines, Ain Shams University	

Date: / / 2020

Statement

This thesis is submitted as a partial fulfilment of Master of Science in Electrical Engineering, Faculty of Engineering, Ain shams University.

The author carried out the work included in this thesis, and no part of it has been submitted for a degree or a qualification at any other scientific entity.

Student name

Walid Ali Mohamed Ahmed Hatahet

Signature

…………..……….

Date: / / 2020

Researcher Data

Name	: Walid Ali Mohamed Ahmed Hatahet
Date of birth	: 23- August - 1993
Place of birth	: Monufia
Last academic degree	: Bachelor of Science in Electrical Engineering
Field of specialization	: Electrical power and machines
University issued the degree	: Ain Shams University
Date of issued degree	: 2016
Current job	: Demonstrator

Thesis Summary

Recently, the DC microgrid has grasped more attention due to its inherent advantages such as high reliability, increased efficiency and simple control. However, voltage regulation and proper current sharing are considered the major issues associated with the DC microgrid. Also, enhancing the closed-loop performance of the power converter of each DG represents the main challenge for the DC microgrids. Hence, a hierarchal control scheme is adopted to overcome these challenges. The primary loop is utilized to control the inner-loop of each DG and the droop method is adopted in this loop. The tertiary loop is used to account for the deviation in voltage occurred due to the droop characteristics and control the power flow in the grid-connected mode. Finally, an outer loop is used to adjust the droop characteristics and control the power sharing of each DG in the microgrid.

In this thesis a rating- based control strategy is presented in order to adjust the power shared by the committed DGs in the DC microgrid. The droop characteristic is adjusted based on the size of each DG and the power sharing is determined based on its rating.

A distributed cost-based control strategy is introduced in order to minimize the total generation cost. The power sharing is adjusted based on the cost function of each DG. The incremental cost method is utilized in a distributed scheme, and the optimal generation is reached when all DGs reach a consensus value of the incremental cost.

In order to enhance the closed-loop performance of the power converter, two control techniques are introduced. A finite-state-machine based controller is developed to control the inner-loop of the dc/dc boost converter of each DG. In this method, the converter can be in certain states based on the relative values of two consecutive samples of the output voltage and the reference voltage signal. The advantages of this method are the simplicity of control and that the controller operates in a voltage mode, thus no current sensors are required.

Moreover, an output voltage tracking performance recovery based controller is developed to improve the closed-loop performance of the power converter of each DG. In this method, disturbance observers are designed based on multivariable approach to account for model mismatches and uncertainties. The controller estimates and cancels the disturbances due to parameters and load variations. The advantages of this method are fast dynamic response and the elimination of steady state errors without the use of integrators.

The feasibility and the robustness of the proposed control schemes are investigated by means of simulation studies using PSCAD/EMTDC package.

Key words: DC microgrid, Distributed generator, Economic dispatch, Incremental cost, Grid-connected, Droop characteristics, Finite-state-machine, Performance recovery.

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Walid Ali Hatahet

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