

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)

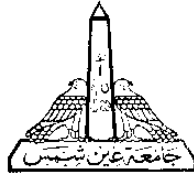
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Statement

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.

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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 hierarchical 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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Table of Contents

Chapter 1	1
Introduction.....	2
1.1 Smart grid.....	2
1.2 Microgrids.....	4
1.3 Classification of microgrids	5
1.3.1 AC microgrids.....	5
1.3.2 DC microgrids.....	6
1.3.3 Hybrid microgrids.....	6
1.4 Hierarchal control schemes	7
1.5 Distributed control scheme fundamentals.....	10
1.5.1 Graph theory	10
1.5.2 Consensus algorithm.....	10
1.6 Literature background and work motivation.....	11
1.7 Thesis objective	14
1.8 Thesis outline	15
Chapter 2	16
Rating-based control of DC microgrids.....	17
2.1 Introduction.....	17
2.2 Rating-based control strategy.....	17
2.2.1 The primary loop.....	17
2.2.2 The tertiary control loop	19
2.2.3 The current sharing loop	21
2.3 Case study (1): two DGs microgrid	21
2.4 Case study (2): three DGs microgrid	24
2.5 Summary	27
Chapter 3	28
Distributed consensus cost-based control strategy of DC microgrids.....	29
3.1 Introduction.....	29
3.2 Economic power dispatch strategy	29
3.3 The proposed distributed economic consensus controller	31
3.3.1 The EDP loop.....	32
3.3.2 The modified EDP loop	33
3.4 case study (1): Two DGs microgrid.....	34
3.5 Case study (2): three DGs microgrid	38
3.6 Summary	41
Chapter 4	42

Performance recovery output voltage tracking controller of DC microgrid	43
4.1 Introduction.....	43
4.2 Finite-state-machine control method.....	43
4.3 Output voltage tracking Performance recovery controller.....	46
4.4 Case study (1): two DGs microgrid	48
4.4.1 Rating-based strategy (FSM based control).....	49
4.4.2 Rating-based strategy (performance recovery controller).....	50
4.4.3 Cost-based strategy (performance recovery controller).....	52
4.5 Case study (2): three DGs microgrid	53
4.5.1 Rating-based strategy (performance recovery controller).....	53
4.5.2 Cost-based strategy (Output voltage tracking performance recovery controller)	55
4.6 Comparison between classic controllers and performance recovery output voltage tracking controller	56
4.6.1 Two DGs microgrid	56
4.6.2 Three DGs microgrid	59
4.6.3 Testing the performance recovery controller against parameters variations.....	61
4.7 Summary	64
Chapter 5	65
Conclusion and future work	66
5.1 Conclusion	66
5.2 Future work.....	66
References	67

List of Figures

Fig. 1.1 Smart grid diagram.	3
Fig. 1.2 Fundamental structure of microgrids.	4
Fig. 1.3 Basic structure of AC microgrids.	5
Fig. 1.4 Basic structure of DC microgrids.	6
Fig. 1.5 Basic structure of Hybrid microgrids.	7
Fig. 1.6 Hierarchal control scheme.	8
Fig. 1.7 Centralized coordination control systems.	8
Fig. 1.8 Decentralized coordination control systems.	9
Fig. 1.9 Distributed coordination control systems.	10
Fig. 2.1 Block diagram of the primary loop.	18
Fig. 2.2 Droop gain adjusting method.	18
Fig. 2.3 Nominal voltage shifting method.	19
Fig. 2.4 Average voltage through shifting droop characteristics	19
Fig. 2.5 Islanded and grid connected modes of operation.	20
Fig. 2.6 Current sharing loop.	21
Fig. 2.7 Two DGs microgrid rating-based control.	23
Fig. 2.8 Three DGs microgrid cost-based control.	25
Fig. 3.1 Block diagram of the proposed cost-based strategy.	31
Fig. 3.2 Block diagram of proposed EDP loop.	32
Fig. 3.3 Modified block diagram of proposed EDP loop.	34
Fig. 3.4 Changes in the communication network.	34
Fig. 3.5 Two DGs microgrid using cost-based	35
Fig. 3.6 Two DGs microgrid with inequality constraints, cost-based.	37
Fig. 3.7 Three DGs microgrid cost-based control.	38
Fig. 3.8 Three DGs microgrid with inequality constraints and cost-based control.	40
Fig. 4.1 Block diagram of FSM controller.	44
Fig. 4.2 Examples of Current and next states	44
Fig. 4.3 Modified block diagram of FSM controller.	46
Fig. 4.4 Block diagram of DC microgrid with the performance recovery controller.	47
Fig. 4.5 Block diagram of the performance recovery controller.	47
Fig. 4.6 Two DGs microgrid using the FSM controller with the rating-based strategy.	50
Fig. 4.7 Two DGs microgrid using the performance recovery controller, rating-based	51
Fig. 4.8 Two DGs microgrid using the performance recovery controller, cost-based strategy	52
Fig. 4.9 Three DGs microgrid using the performance recovery controller, rating-based strategy.	54
Fig. 4.10 Three DGs microgrid using the performance recovery controller, cost-based strategy	55
Fig. 4.11 Two DGs microgrid with rating-based strategy: PI and performance recovery controller	57
Fig. 4.12 Two DGs microgrid with cost-based strategy: PI and performance recovery controller	58
Fig. 4.13 Three DGs microgrid with rating-based strategy: PI and performance recovery controller .	59
Fig. 4.14 Three DGs microgrid with cost-based strategy: PI and performance recovery controller	60
Fig. 4.15 Two DGs microgrid using performance recovery controller with rating-based strategy : parameters variations	61
Fig. 4.16 Two DGs microgrid using performance recovery controller with cost-based strategy : parameters variations	63

List of Tables

Table 2.1 Electrical parameters of rating-based two DGs microgrid.	22
Table 2.2 Cost function parameters of rating-based two DGs microgrid.....	22
Table 2.3 Electrical parameters of rating-based three DGs microgrid.	24
Table 2.4 Cost function parameters of rating-based three DGs microgrid.....	24
Table 4.1 Rules for Duty cycle update decisions.....	44