UNIVERSITI PUTRA MALAYSIA

OPTIMISATION OF DISTRIBUTED GENERATION IN ELECTRIC POWER SYSTEMS USING FUZZY-GENETIC ALGORITHM APPROACH

MUDATHIR FUNSHO AKOREDE

FK 2011 66
OPTIMISATION OF DISTRIBUTED GENERATION IN ELECTRIC POWER SYSTEMS USING FUZZY-GENETIC ALGORITHM APPROACH

By

MUDATHIR FUNSHO AKOREDE

Thesis Submitted to the School of Graduate Studies, Universiti Putra Malaysia, in Fulfilment of the Requirements for the Degree of Doctor of Philosophy

August 2011
DEDICATION

This thesis is dedicated to my parents, late Alhajj Salahu-deen Akorede and Madam Sefinat Akorede, for their inestimable contributions in my life.
Abstract of thesis presented to the Senate of Universiti Putra Malaysia in fulfilment of the requirement for the degree of Doctor of Philosophy.

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August 2011

Chairman: Hashim Hizam, PhD

Faculty: Engineering

To maximise the benefits offered by distributed generation (DG) in electric power systems, there is clearly a need to determine the optimum size, as well as the best site of that particular DG unit(s) in the network. Recent research has shown that improper placement of DG units in power systems would not only lead to an increased energy loss cost, but could also jeopardize the system operation. To avert these scenarios and tackle this optimisation problem, this thesis proposes two models to guide electric utilities in determining the optimal capacity and location of DG units in power networks.

The first model for meshed electric power networks, which could be employed for subtransmission networks operating at up to 132 kV level, uses two objective
functions. The model maximises the system loading margin as well as the profit of the distribution company (DISCO) over the planning period. The other model is designed for radial distribution networks operating at 33 kV and below voltage levels. The main objective functions considered in this model are maximisation of cost savings arising from energy loss, minimisation of line voltage drop, and maximisation of the transfer capability of the system. This model takes into account, the peculiarities of radial distribution networks, such as high R/X (resistance/reactance) ratio, voltage dependency and composite nature of loads.

To solve the proposed models, Genetic algorithm (GA) is used as an optimisation technique. In the GA, a fuzzy controller is used to dynamically adjust the crossover and mutation rates to maintain the proper population diversity (PD) during GA’s operation. This effectively overcomes the premature convergence problem of the simple genetic algorithm (SGA). The accuracy of the proposed models is evaluated on test power systems, and the results obtained are compared with those of the existing approaches cited in this literature, which is highly impressive.

This thesis also investigates the impact of different penetration levels of DG in both subtransmission and distribution networks. In the study, a 15-bus test system is employed and modelled in detail using Power System Analysis Toolbox (PSAT). However, only synchronous type of DGs is considered since it is the most popular type in use. In this work, the impact of DG of different penetration levels on system stability and power quality are thoroughly examined under different fault scenarios. The results obtained suggest that 20% penetration level of DG is optimal for both normal and during contingencies in the case study system.
This research work is concluded with a software development. The package called Power Flow Analysis and DG Optimisation Tool (PFADOT) is developed using the Graphical User Interface (GUI) of MATLAB. This provides a user friendly interface for the system operator in determining the optimal allocation of a single DG unit in radial distribution networks. The evolved package is tested with several test systems, and the results obtained are validated against an existing related package. The developed package does not only give more optimal results but also does that in a more computationally efficient manner.
Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk ijazah Doktor Falsafah.

PENGOPTIMUMAN PENJANAAN TERAGIH DALAM SISTEM KUASA ELEKTRIK MENGGUNAKAN PENDEKATAN ALGORITMA GENETIK SAMAR

Oleh

MUDATHIR FUNSHO AKOREDE

Ogos 2011

Pengerusi: Hashim Hizam, PhD

Fakulti: Kejuruteraan

Untuk memaksimumkan keuntungan yang ditawarkan oleh penjanaan teragih (DG) dalam sistem kuasa elektrik, jelas ada keperluan untuk menentukan saiz yang optimum, serta lokasi terbaik untuk sesuatu unit DG dalam rangkaian. Penyelidikan terkini menunjukkan bahawa penempatan unit DG yang tidak sesuai dalam sistem kuasa tidak hanya akan mengarah pada peningkatan kos tenaga yang hilang, tetapi juga boleh membahayakan sistem operasi. Untuk mengelakkan senario ini dan mengatasi masalah pengoptimuman, tesis ini mencadangkan dua model untuk memberi panduan kepada utiliti elektrik dalam menentukan kapasiti optimum dan lokasi DG dalam rangkaian elektrik.

Model pertama untuk rangkaian kekisi kuasa elektrik, yang boleh digunakan untuk rangkaian subtransmisi beroperasi hingga tahap 132 kV menggunakan dua fungsi
objektif. Model tersebut memaksimumkan margin beban sistem, serta keuntungan daripada syarikat pengedaran (DISCO) selama tempoh perancangan. Satu model lagi di reka untuk rangkaian pengedaran jejari beroperasi pada tahap voltan 33 kV dan ke bawah. Fungsi objektif utama yang dipertimbangkan dalam model ini adalah memaksimumkan penjimatan kos hasil dari kehilangan tenaga, meminimunkan kejatuhan voltan talian, serta memaksimumkan kemampuan pemindahan sistem. Model ini mengambil kira keunikan rangkaian pengedaran jejari, seperti nisbah R/X (rintangan bahagi reaktans) yang tingi, kebergantungan voltan dan sifat komposit beban.

Untuk menyelesaikan model yang dicadangkan, Algoritma Genetik (GA) digunakan sebagai satu teknik pengoptimuman. Dalam GA, pengawal samar digunakan secara dinamik untuk menyesuaikan kadar silang dan mutasi untuk memelihara kepelbagaian penduduk yang tepat (PD) selama operasi GA. Ini dapat mengatasi masalah penumpuan pramasa algoritma genetik ringkas (SGA). Ketepatan model yang dicadangkan dinilai pada sistem kuasa, dan hasil yang diperolehi dibandingkan dengan pendekatan yang sedia ada, adalah sangat baik.

Keputusan yang diperolehi menunjukkan bahawa 20% tingkat penetrasi DG adalah nilai optima bagi kajian kes untuk keadaan normal dan kontingensi.

Penyelidikan ini diakhiri dengan pembangunan perisian. Perisian yang dinamakan Power Flow Analysis and DG Optimization Tool (PFADOT) dibangunkan dengan menggunakan Graphical User Interface (GUI) dari MATLAB. Ia merupakan antara muka yang mudah digunakan oleh operator sistem dalam menentukan peruntukan optima unit DG tunggal dalam rangkaian pengedaran jejari. Perisian ini diuji dengan beberapa sistem ujian, dan hasil yang diperolehi disahkan dengan membandingkan dengan perisian yang sedia ada. Perisian yang dibangunkan bukan sahaja memberi keputusan yang optima tetapi juga melakukan dengan lebih efisen.
ACKNOWLEDGEMENTS

Man proposes but God disposes. All praise and thanks are due to the Almighty ALLAH (SWT), for giving me the grace, health and strength to pursue my PhD degree programme to a logical conclusion – *al-hamdulillah Robil alamin.*

Further, my bundle of appreciation goes to my supervisor, who is equally the Head of Electrical and Electronic Engineering Department, Universiti Putra Malaysia, Assoc. Prof. Dr. Hashim Hizam for his tremendous contribution and assistance in the course of this programme. His invaluable advice and encouragements have really contributed immensely to the success and completion of this programme in good time. Similarly, the financial assistance in form of Special Graduate Research Assistantship (SGRA) you offered in my second semester, which had a great impact on my academic and financial stability during the trying period, is gratefully acknowledged. May the Almighty Allah (SWT) reward you abundantly for this kind gesture.

In the same vein, I’m deeply grateful to my amiable Supervisory Committee Members, Prof. Dr. Ishak Aris and Assoc. Prof. Dr. Mohd. Zainal A. Ab Kadir, both of Electrical and Electronic Engineering Department, Universiti Putra Malaysia, for their availability, invaluable advices, constructive feedbacks and overall assistance to ensure that this thesis is of a high quality. Oh, I could not have had a better team. Other eminent lecturers, the technical staff and the entire support staff in the Department are equally appreciated for the good working relationship I enjoyed from them throughout my PhD programme in the Department.
Special thanks go to the Nigerian Community in UPM, popularly known as NaijaComm. Specifically, I wish to acknowledge and place in record the support received from Abdul-Fatah Akande, Tajudeen Ishola, Abdul-Hakeem Olaniyi, Aliyu Usman, Mohd Lawal Sani, Mrs Mariam Ahmed, Buba Sani Dahiru, Umar-Faruku Ambrusa, Wasiu Arolu and Peter Adeoye. Similarly, I wish to express my gratitude to my laboratory mates for the good working relationship we had during the period of my stay in the lab. They include Mojgan Hojabri, Khairi Budayawan, Syed Abdul-Bari, Lioe De Xing, Tan Gim Heng, and Tung Li Qian.

The technical advice, motivation and guidance received from Prof J. O. Ojo of Tennessee Technological University, USA and the moral and academic material support offered by Prof O. U. Aliyu of ATBU Bauchi Nigeria, in the course of this programme are acknowledged with appreciations. Furthermore, the kind of love, moral and material support given by Bisi Aina to my left behind family in Nigeria is gratefully acknowledged and appreciated. Indeed it is very hard to find your type of a true friend these days. As a matter of fact, you are a rare friend!

I wish to thank the School of Graduate Studies, Universiti Putra Malaysia (UPM) for facilitating this programme with its series of workshops, seminars, conferences, etc, organised free of charge with provision of adequate makan from time to time, by which postgraduate students are better and well informed of all it takes to successfully complete graduate degree programme at UPM in good time. In the same vein, the financial assistance in form of Graduate Research Fellowship (GRF), offered by the Universiti Putra Malaysia is gratefully acknowledged.
Finally, I express my utmost gratitude to my beloved wife, Mujidat Bukola, for her care, love, inspirational words, continual prayers and moral support. This equally goes to my boys, Abdul-Hameed, Abdul-Ahad and especially Abdus-Samad whom I left with his mother at the age 5 months when I started this programme in July 2008. I am thankful of your perseverance and understanding especially at the time you needed me most as a husband and father respectively. My profound gratitude equally goes to my brothers, sisters, nephews, nieces and the entirety of the extended family. In like manner, I wish to express my profound gratitude to my in-laws, family friends and all my well wishers, for their understanding, moral and material support in various forms, to my nuclear family during my 3-year sojourn in Malaysia. Thank you all; God bless.

M. F. Akorede

August 2011
I certify that a Thesis Examination Committee has met on 3rd August, 2011 to conduct the final examination of Mudathir Funsho Akorede on his degree thesis entitled “Optimisation of Distributed Generation in Electric Power Systems using Fuzzy-Genetic Algorithm Approach” in accordance with the Universities and University College Act 1971 and the Constitution of the Universiti Putra Malaysia [P. U. (A) 106] 15 March 1998. The Committee recommends that the student be awarded the Doctor of Philosophy.

Members of the Examination Committee were as follows:

**Roslina bt. Mohd. Sidek, PhD**
Associate Professor  
Faculty of Engineering  
Universiti Putra Malaysia  
(Chairman)

**Ir. Norman b. Mariun, PhD**
Professor  
Faculty of Engineering  
Universiti Putra Malaysia  
(Internal Examiner)

**Chandima Gomes, PhD**
Associate Professor  
Faculty of Engineering  
Universiti Putra Malaysia  
(Internal Examiner)

**Govinda Bol Shrestha, PhD**
Associate Professor  
School of Electrical & Electronic Engineering  
Nanyang Technological University, Singapore  
(External Examiner)

---

**NORITAH OMAR, PhD**  
Associate Professor and Deputy Dean  
School of Graduate Studies  
Universiti Putra Malaysia

Date: 23rd August, 2011
This thesis was submitted to the Senate of Universiti Putra Malaysia and has been accepted as fulfilment of the requirement for the degree of Doctor of Philosophy. The members of the Supervisory Committee were as follows:

**Hashim Hizam, PhD**
Associate Professor  
Faculty of Engineering  
Universiti Putra Malaysia  
(Chairman)

**Ishak Aris, PhD**
Professor  
Faculty of Engineering  
Universiti Putra Malaysia  
(Member)

**Mohd Zainal Abidin Ab Kadir, PhD**
Associate Professor  
Faculty of Engineering  
Universiti Putra Malaysia  
(Member)

______________________________  
HASANAH MOHD. GHAZALI, PhD  
Professor and Dean  
School of Graduate Studies  
Universiti Putra Malaysia  

Date:
DECLARATION

I declare that the thesis is my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously, and is not concurrently, submitted for any other degree at Universiti Putra Malaysia or at any other institution.

________________________________
MUDATHIR FUNSHO AKOREDE

Date: 3rd August, 2011
# TABLE OF CONTENTS

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>DEDICATION</td>
<td>ii</td>
</tr>
<tr>
<td>ABSTRACT</td>
<td>iii</td>
</tr>
<tr>
<td>ABSTRAK</td>
<td>vi</td>
</tr>
<tr>
<td>ACKNOWLEDGEMENTS</td>
<td>ix</td>
</tr>
<tr>
<td>CERTIFICATION</td>
<td>xii</td>
</tr>
<tr>
<td>APPROVAL</td>
<td>xiii</td>
</tr>
<tr>
<td>DECLARATION</td>
<td>xiv</td>
</tr>
<tr>
<td>TABLE OF CONTENTS</td>
<td>xv</td>
</tr>
<tr>
<td>LIST OF TABLES</td>
<td>xix</td>
</tr>
<tr>
<td>LIST OF FIGURES</td>
<td>xx</td>
</tr>
<tr>
<td>LIST OF ABBREVIATIONS</td>
<td>xxiv</td>
</tr>
</tbody>
</table>

## CHAPTER

1 INTRODUCTION  
1.1 Background of the Study 1  
1.2 Problem Statement 5  
1.3 Objectives of the Study 6  
1.4 Motivation 7  
1.5 Main Contributions 8  
1.6 Organisation of the Thesis 10  

2 DISTRIBUTED ENERGY RESOURCES OVERVIEW  
2.1 Introduction 12  
2.2 Distributed Energy Resources (DER) 12  
2.2.1 Distributed Generation Technologies 13  
2.2.2 Energy Storage Technologies 29  
2.3 Potential Benefits of DG 37  
2.3.1 Higher Energy Efficiencies 37  
2.3.2 Increased System Reliability 39  
2.3.3 Alternative to Transmission and Distribution
Expansion
2.3.4 Peak Period Shaving 40
2.3.5 Environmental Impact Reduction 40
2.3.6 Minimises Damage to Health 42
2.3.7 Space Advantage 42
2.3.8 Others 43
2.4 The Challenges Facing DG 43
2.4.1 Public Policies and Regulatory Issues 43
2.4.2 Economic Issues 44
2.4.3 Technical Issues 45
2.5 Conclusion 50

3 QUANTITATIVE AND QUALITATIVE ANALYSIS OF SYSTEM STABILITY AND POWER QUALITY IN NETWORKS WITH DG OF DIFFERENT PENETRATION LEVELS 51
3.1 Introduction 51
3.2 Network Description and Components Modelling 54
3.2.1 Power System Description 54
3.2.2 DG Penetration Level 56
3.2.3 Components Modelling 56
3.3 Impact of DG on Power Loss 60
3.4 Stability Analysis 61
3.4.1 Transient Stability 61
3.4.2 Frequency Stability 68
3.4.3 Voltage Stability 71
3.5 Power Quality Issues 72
3.5.1 Steady-State Voltage Regulation 73
3.5.2 Voltage Sags 74
3.6 Conclusion 78

4 EFFECTIVE METHOD FOR OPTIMAL ALLOCATION OF DISTRIBUTED GENERATION UNITS IN MESHED ELECTRIC POWER SYSTEMS 80
4.1 Introduction 82
4.2 Problem Formulation  
4.2.1 Objective Functions  
4.2.2 Loading Margin Maximisation  
4.2.3 Profit Maximisation  
4.2.4 Membership Function for the Objective Functions  
4.3 Brief Overview of Genetic Algorithm  
4.4 The Proposed Algorithm for DG Placement  
4.5 Application to Test Systems  
4.6 Results and Discussion  
4.6.1 Case 1 – 6-Bus Test System  
4.6.2 Case 2 – 30-Bus Test System  
4.7 Conclusion  

5 A FUZZY GENETIC ALGORITHM-BASED MODEL FOR OPTIMAL PLACEMENT OF DISTRIBUTED GENERATION IN A RADIAL DISTRIBUTION NETWORK  
5.1 Introduction  
5.2 Problem Formulation  
5.2.1 Energy Loss Cost Savings (ELCS) Maximisation  
5.2.2 Line Voltage Drop (LVD) Minimisation  
5.2.3 Power Transfer Capability (PTC) Maximisation  
5.2.4 The Multi-Objective Function (MOBF)  
5.3 Power Flow Method  
5.4 A Brief Overview of Fuzzy genetic Algorithm  
5.4.1 Genetic Algorithm (GA)  
5.4.2 Fuzzy Set Theory  
5.5 The Proposed Algorithm  
5.6 Application to Test Networks  
5.6.1 Case 1 – 30-Bus Radial Distribution System  
5.6.2 Case 2 – 69-Bus Radial Distribution System  
5.7 Results Comparison with Other Approaches  
5.8 Conclusion
6 A WINDOWS-BASED TOOL FOR POWER FLOW ANALYSIS AND DG OPTIMISATION IN RADIAL DISTRIBUTION NETWORKS

6.1 Introduction 140
6.2 Objective Function Formulation 144
6.3 DG Placement Algorithm 146
6.4 Software Development Procedure 148
  6.4.1 Designing a GUI 149
  6.4.2 Starting GUIDE 150
  6.4.3 Adding Components to a GUI 151
  6.4.4 Programming a GUI 152
  6.4.5 Software Development Process Limitation 152
6.5 Software Descriptions 153
6.6 Results and Discussion 159
  6.6.1 Case study I – 12-Bus System 159
  6.6.2 Case study II – 30-Bus System 160
  6.6.3 Case study III – 69-Bus System 161
6.7 Conclusion 164

7 CONCLUSIONS AND RECOMMENDATIONS FOR FUTURE RESEARCH 165

7.1 Conclusions 165
7.2 Recommendations for Future Research 166

REFERENCES 168
APPENDICES 188
  Appendix A 189
  Appendix B 190
  Appendix C1 192
  Appendix C2 194
  Appendix D 196

BIODATA OF STUDENT 199
LIST OF PUBLICATIONS AND AWARDS FROM THE STUDY 200