

Modern Optimisation Techniques in Power Systems

International Series on
MICROPROCESSOR-BASED AND
INTELLIGENT SYSTEMS ENGINEERING

VOLUME 20

Editor

Professor S. G. Tzafestas, *National Technical University, Athens, Greece*

Editorial Advisory Board

Professor C. S. Chen, *University of Akron, Ohio, U.S.A.*

Professor T. Fokuda, *Nagoya University, Japan*

Professor F. Harashina, *University of Tokyo, Tokyo, Japan*

Professor G. Schmidt, *Technical University of Munich, Germany*

Professor N. K. Sinha, *McMaster University, Hamilton, Ontario, Canada*

Professor D. Tabak, *George Mason University, Fairfax, Virginia, U.S.A.*

Professor K. Valavanis, *University of Southern Louisiana, Lafayette, U.S.A.*

The titles published in this series are listed at the end of this volume.

Modern Optimisation Techniques in Power Systems

edited by

YONG-HUA SONG

*Department of Electrical Engineering and Electronics,
Brunel University,
West London, U.K.*



SPRINGER-SCIENCE+BUSINESS MEDIA, B.V.

A C.I.P. Catalogue record for this book is available from the Library of Congress.

ISBN 978-90-481-5216-2 ISBN 978-94-015-9189-8 (eBook)
DOI 10.1007/978-94-015-9189-8

Printed on acid-free paper

All Rights Reserved
© 1999 Springer Science+Business Media Dordrecht
Originally published by Kluwer Academic Publishers in 1999
Softcover reprint of the hardcover 1st edition 1999

No part of the material protected by this copyright notice may be reproduced or utilized in any form or by any means, electronic or mechanical, including photocopying, recording or by any information storage and retrieval system, without written permission from the copyright owner

CONTENTS

Preface	ix
Contributors	xi
Chapter 1 Introduction	1
<i>Y.H. Song</i>	
1.1 Power system optimisation	1
1.2 Emerging optimisation techniques	4
1.3 Applications in power systems	12
1.4 References	12
Chapter 2 Simulated annealing applications	15
<i>K. Nara</i>	
2.1 Introduction	15
2.2 What is simulated annealing	16
2.3 Power system applications	22
2.4 Concluding remarks	36
2.5 References	36
Chapter 3 Tabu search application in fault section estimation and state identification of unobserved protective relays in power system	39
<i>F. Wen, C.S. Chang</i>	
3.1 Introduction	39
3.2 The overall approach for FSE-SIUPR	42
3.3 The mathematical model for FSE-SIUPR	42
3.4 Tabu search with application to FSE-SIUPR	48
3.5 Test results	53
3.6 Conclusions	55
3.7 Appendix	55
3.8 References	59
Chapter 4 Genetic algorithms for scheduling generation and maintenance in power systems	63
<i>C.J. Aldridge, K.P. Dahal, J.R. McDonald</i>	

4.1 Genetic algorithm	63
4.2 A knowledge-based genetic algorithm for Unit Commitment	68
4.3 Generator maintenance scheduling using a genetic algorithm	77
4.4 Acknowledgements	86
4.5 References	86

Chapter 5 Transmission network planning using genetic algorithms 91

M.R. Irving, H.M. Chebbo, S.O. Orero

5.1 Introduction	91
5.2 Genetic algorithm	91
5.3 The transmission network planning problem	103
5.4 Experimental results	107
5.5 Future work	109
5.6 Conclusions	109
5.7 Acknowledgement	110
5.8 References	110

Chapter 6 Artificial neural networks for generation scheduling 113

M.P. Walsh, M.J. O'Malley

6.1 Introduction	113
6.2 Hopfield networks	113
6.3 Hopfield networks applied to the scheduling problem	116
6.4 Augmented Hopfield network	123
6.5 Applications of the augmented Hopfield network to the scheduling problem	125
6.6 Other neural network approaches to the scheduling problem	135
6.7 Conclusions	137
6.8 References	137

Chapter 7 Decision making in a deregulated power environment based on fuzzy sets 141

S.M. Shahidehpour, M.I. Alomoush

7.1 Fuzzy sets: introduction and background	141
7.2 Fuzzy multiple objective decision	142
7.3 Analytical hierarchy process	145
7.4 Applications of fuzzy set	148

7.5 Decision making in a deregulated power environment based on fuzzy set	154
7.6 References	168

Chapter 8 Lagrangian relaxation applications to electric power operations and planning problems 173

A.J. Conejo, J.M.Arroyo, N. Jiménez Redondo, F.J. Prieto

8.1 Introduction	173
8.2 Lagrangian relaxation	173
8.3 Augmented Lagrangian decomposition	181
8.4 Short-term hydro-thermal co-ordination and unit commitment	183
8.5 Decentralized optimal power flow	189
8.6 Medium /long-term hydro-thermal co-ordination problem	194
8.7 References	200

Chapter 9 Inter point methods and applications in power systems 205

K Xie, Y.H. Song

9.1 Introduction	205
9.2 Interior point methods	205
9.3 Power system applications	220
9.4 Implementation issues	232
9.5 A case study on IPM based spot pricing algorithm	236
9.6 Conclusions	241
9.7 Acknowledgement	241
9.8 References	241

Chapter 10 Ant colony search, advanced engineered-conditioning genetic algorithms and fuzzy logic controlled genetic algorithms: economic dispatch problems 247

Y.H. Song, C.S.V. Chou, I.K. Yu, G.S. Wang

10.1 Introduction	247
10.2 Ant colony search algorithms	247
10.3 Engineered-conditioning GAs	251
10.4 Fuzzy logic controlled genetic algorithms	254
10.5 Test results on economic dispatch problems	255
10.6 Some remarks	258

10.7	References	259
------	------------	-----

Chapter 11 Industrial applications of artificial intelligence techniques

<i>A O. Ekwue</i>		261
11.1	Introduction	261
11.2	Algorithmic methods versus artificial intelligence techniques	262
11.3	Artificial intelligence techniques	263
11.4	Conclusions	270
11.5	Acknowledgement	271
11.6	References	272

PREFACE

The electric power industry is currently undergoing an unprecedented reform. The deregulation of electricity supply industry has introduced new opportunity for competition to reduce the cost and cut the price. It is a tremendous challenge for utilities to maintain an economical and reliable supply of electricity in such an environment. Faced by an increasingly complicated existence, power utilities need efficient tools and aids to ensure that electrical energy of the desired quality can be provided at the lowest cost. The overall objective, both for short-term and long-term operations, is then to find the best compromise between the requirements of security and economy. That is, effective tools are urgently required to solve highly constrained optimisation problems.

In recent years, several major modern optimisation techniques have been applied to power systems. A large number of papers and reports have been published. In this respect, it is timely to edit a book on this topic with an aim to report the state of the art development internationally in this area. Chapter 1 introduces the subject of the book by commenting on major modern optimisation techniques covered in the book. They are: simulated annealing, tabu search, genetic algorithms, neural networks, fuzzy programming, Lagrangian relaxation, interior point methods, ant colony search and hybrid techniques. From chapters 2 to 10, detailed descriptions of these modern optimisation techniques together with various power system applications are presented, which clearly demonstrate the potential and procedures of applying such techniques in solving complex power system optimisation problems. The final chapter, Chapter 11, gives an industrial view on applications of some of the techniques. The book is structured so that it is useful to a range of readers, covering basic algorithms as well as applications and case studies.

The Editor would like to thank the authors who submitted their work for inclusion in the book, and Catherine Murphy of Kluwer Academic Publishers for the help in the production of the book.

Professor Yong-Hua Song
Brunel University, London, UK

CONTRIBUTORS

**Y.H. Song, M.R. Irving, K. Xie,
H. M. Chebbo, S. O. Orero,
C.S.V. Chou, I.K. Yu and G.S.
Wang**

Dept. Of Electrical Engineering
Brunel University
Uxbridge
UB8 3PH, UK

K. Nara

Dept. of System Engineering
Ibaraki University
12-1 Nakanarusawa 4 Chome
Hitachi 316-8511 Japan

Fushuan Wen

Dept. of Electrical Engineering
Zhejiang University
Hangzhou, 310027
Zhejiang Province
P.R.China

C.S. Chang

Dept. of Electrical Engineering
National University of
Singapore
10 Kent Ridge Crescent
Singapore 119260
Republic of Singapore

**C.J. Aldridge, K.P. Dahal, J.R.
McDonald**

Centre for Electrical Power
Engineering

University of Strathclyde,
Glasgow, G11XW, UK

**Michael P. Walsh And Mark J.
O'Malley**

Department of Electrical
Engineering
University College, Dublin,
Ireland

**S. M. Shahidehpour And M. I.
Alomoush**

Department of Electrical and
Computer Engineering
Illinois Institute of Technology
Chicago, IL 60616

A.J. Conejo And J.M.Arroyo
ETSII, Univ. Castilla-La Mancha
Ciudad Real, 13071, Spain

N. Jiménez Redondo

Univ. De Málaga
Málaga, Spain

F.J. Prieto

Univ. Carlos Iii
Madrid, Spain

A.O. Ekwue

National Grid Company plc,
RG41 5BN, UK