UNIVERSITI TEKNOLOGI MARA

EMBEDDED META EVOLUTIONARY-FIREFLY ALGORITHM-ANN FOR MULTI DG PLANNING IN DISTRIBUTION SYSTEM

SITI RAFIDAH BINTI ABDUL RAHIM

Thesis submitted in fulfillment
of the requirements for the degree of
Doctor of Philosophy
(Electrical Engineering)

Faculty of Electrical Engineering

January 2019

ABSTRACT

The depletion of fossil fuel and climate change challenge has gathered worldwide effort to develop sustainable energy systems. Several issues such as energy efficiency, environmental impact and security of supply are the major concerns when dealing with the DG installation. As a result, the penetration of DG in the electricity network will increase and may affect the system. In light of this, various forms of Distributed Generation (DG) technologies have been connected to the system, either to the transmission or distribution system. The installation of DG requires optimisation process to identify the correct location and sizing. Improper sizing and location of DG installation may result to overcompensation or under compensation. Most optimisation techniques are found to face inaccurate and stucked at local minimum phenomena with computationally burdensome. Thus, a reliable optimisation technique is crucial to address this issue. This thesis presents a novel Embedded Meta Evolutionary–Firefly Algorithm-Artificial Neural Network for Multi-DG planning in distribution system. In this study, Meta Evolutionary–Firefly Algorithm (EMEFA) was initially developed to expedite the computational time in multi-DG installation with improved accuracy. Optimal location and sizing are determined using the proposed EMEFA technique. Consequently, a new clustering technique was developed to categorise the DG placement in accordance with different DG types and DG models. Load in the distribution system is divided into three categories i.e. residential, commercial and industrial. These three load types are voltage dependent, and active and reactive power components respond differently to variations in voltage. The voltage dependent load has a main impact on distribution system planning studies. In achieving optimal allocation of DG, two techniques were proposed to study the DG planning which is the ranking identification for DG installation and the integrated clustering development and pre-developed EMEFA was employed. The aim of the technique is to reduce the computational time during the optimisation process for DG planning along with the total loss minimisation. Artificial neural network (ANN) model was then developed to predict penetration level sensitivity index (PLSI) and loss values. Two separate ANN models have been established for this purpose. PLSI mathematical formulation was newly derived to indicate the penetration level for DG planning purposes. Subsequently, EMEFA-ANN was developed to optimise the weight of the ANN to minimise the mean squared error. All the developed techniques have been compared with respect to several existing techniques and validated on 33-Bus and 69-Bus Radial Distribution Systems. Results produced from the proposed EMEFA technique have indicated that EMEFA outperformed traditional firefly algorithm (FA) and evolutionary programming (EP) in terms reducing the computational time to achieve optimal solution. In addition, the proposed integrated clustering technique has also led to shorter computational time as compared to other techniques for different DG types and models. The amount of percentage of reduction of computational time is between 60% to 90% using the proposed integrated clustering technique as compared to Ranking Identification technique. Subsequently, the proposed PLSI formulation and EMEFA-ANN models have shown reduced rms values with improved correlation coefficient for multi-DG installation. Results obtained from the study could be utilised by the utility and energy commission for loss reduction scheme in distribution system. The power system planner can benefit the suitable size and location from the result obtained in this study with the appropriate company's budget.

ACKNOWLEDGEMENT

In the name of Allah, The Most Merciful and The Most Gracious. Alhamdulillah, syukur to Allah SWT for His blessing and guidance during the preparation of this thesis.

First and foremost, my honest thankfulness and deepest appreciation to my supervisor, Prof. Ir. Dr. Ismail Musirin for his continuous guidance and motivation towards the completion of this research work and thesis. I would also like to express my gratitude to my co-supervisor, Assoc. Prof. Dr. Muhammad Murtadha Othman. I am also grateful for the scholarship provided by Universiti Malaysia Perlis (UniMAP). Appreciation to the Dean of School of Electrical Systems Engineering, UniMAP for the support and motivation. I am also indebted to all my colleagues; Ashikin, Fayzul, Amely, Ashida, Omar, Herwan, Faridun, Azral, Sarah and Yasmin for their constructive comments, supports, and academic discussion during the period of this research.

Last but not least, special thanks and love goes to my beloved mother Pn. Siti Hamsiah Binti Sayed Ramli, my mother in law Pn. Azah Binti Ahmad, my beloved husband Muhamad Hatta Bin Hussain, my brother Mior Ahmad Fauzi Bin Abdul Rahim, my children Muhammad Luqman Hakim and Muhammad Hazim Rizqi for their patience, unconditional support, invaluable motivation and prayer. This thesis is also dedicated to the loving memory of my very dear late father, Allahyarham Abdul Rahim Bin Mat Desa. This piece of victory is dedicated to all of you. Alhamdulillah.

May my humble discoveries give some contributions in this enormous world of knowledge!

TABLE OF CONTENT