UNIVERSITI TEKNOLOGI MARA

MODIFIED FIREFLY ALGORITHM FOR DIRECTIONAL OVERCURRENT RELAY COORDINATION IN POWER SYSTEM PROTECTION

MUHAMAD HATTA BIN HUSSAIN

PhD

April 2020

AUTHOR'S DECLARATION

I declare that the work in this thesis was carried out in accordance with the regulations of Universiti Teknologi MARA. It is original and is the results of my own work, unless otherwise indicated or acknowledged as referenced work. This thesis has not been submitted to any other academic institution or non-academic institution for any degree or qualification.

I, hereby, acknowledge that I have been supplied with the Academic Rules and Regulations for Post Graduate, Universiti Teknologi MARA, regulating the conduct of my study and research.

Name of Student	:	Muhamad Hatta bin Hussain
Student I.D. No.	:	2011349805
Programme	:	Doctor of Philosophy (Electrical Engineering) – EE990
Faculty	:	Electrical Engineering
Thesis Title	:	Modified Firefly Algorithm for Directional Overcurrent Relay Coordination in Power System Protection

Signature of Student	:	……..
Date	:	April 2020

ABSTRACT

Nowadays, modern power systems are interconnected and protected by Directional Overcurrent Relays (DOCRs). Therefore, the protection coordination scheme poses great challenge especially in multi-source networks due to network topology and microprocessor relay. Thus, it becomes very difficult to set the sequence of relay operations for various faults in power system. Moreover, it leads to miscoordination between the primary and backup relay pairs with the occurrence of multi-directional fault current in network. The optimization techniques eliminate the need to find the breakpoints which is applied for setting the relays in coordination process since four decades ago. Most optimization techniques especially the conventional mathematical based optimization is found to face inaccurate and stuck at local minimum phenomenon while it was computationally burdensome. Thus, a reliable optimization technique such as Nature Inspired Metaheuristic Algorithms (NIMA) is crucial to address this issue. This thesis presents Modified Firefly Algorithm for Directional Overcurrent Relay Coordination in Power System Protection. The objectives of the studies are to develop a new optimization technique termed as Modified Firefly Algorithm (MFA) for minimizing the relay operating time, to develop a Multi-Objective Modified Firefly Algorithm (MOMFA) for minimizing both the total relay operating time and relay coordination time and to develop an integrated optimal predictor termed as Modified Firefly Algorithm-Artificial Neural Network (MFA-ANN) for accurate prediction of relay operating time. A new parameter is added into traditional FA in order to speed up the convergence process. All the developed techniques have been validated on the IEEE 8-Bus, WSCC 9-bus and IEEE-14 Bus Transmission Systems. The Electric Transient and Analysis Program (ETAP) was used as the simulation tool, while Matrices Laboratory (MATLAB) was utilized to implement all the algorithms in this study. Subsequently, a new Objective Function is proposed which considers penalty function, total relay operating time and relay coordination time. Comparative studies have been conducted with respect to Multi-Objective Modified Firefly Algorithm (MOMFA), Multi-Objective Artificial Bees Colony (MOABC) and Multi-Objective Particle Swarm Optimization (MOPSO). Results revealed that the MOMFA outperformed MOABC and MOPSO in terms of preventing miscoordination occurrence within less iteration and computational time. In terms of prediction time-current characteristics, the proposed MFA-ANN model has shown the reduction in Root Mean Square Error (RMSE) values which improved the correlation coefficient of the relay operating time. The proposed MFA-ANN model managed to achieve 0% RMSE value. Thus, the protection engineers can benefit from the result in this study. They can utilize the results for the setting, type and coordination protective device to ensure reliable design in terms of security, selectivity, stability and speed.

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. Ir. Dr. Ahmad Farid Abidin. I am also grateful for the scholarship provided by Universiti Malaysia Perlis (UniMAP). Appreciation to the Dean of School of Electrical Systems Engineering, UniMAP, PM Dr Haziah Abdul Hamid for the support and motivation. I am also indebted to all my colleagues; Azralmukmin Azmi, Ir Nurulazmi Abdul Rahman, Jamil Abu Ziyad, Dr. Mohd Rafi Adzman, Dr Mohd Faridun Naim Tajudin, Norhaidar Hashim and Norhasnizam Hanafi 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 Hajah Azah Binti Ahmad, my mother in law Hajah Siti Hamsiah Binti Sayed Ramli, my beloved wife Dr. Siti Rafidah Binti Abdul Rahim, my brothers Muhamad Huzaimi Bin Hussain, Muhamad Zulhilmi Bin Hussain and sister Nur Nadirah Binti Hussain, my brother in law Mior Ahmad Fauzi Bin Abdul Rahim and Muhammad Syafiq Razwan Bin Sulaiman, my sister in law, Kasrina Binti Muhid and my beloved 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 Haji Hussain Bin Abdul Rahman. During my third year study, he was diagnosed with colon cancer. Never forget difficulties during the two years before he passed away. This piece of victory is dedicated to all of you. Alhamdulillah.

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

MUHAMAD HATTA BIN HUSSAIN

APRIL 2020

TABLE OF CONTENTS