UNIVERSITI TEKNOLOGI MARA

ENERGY EFFICIENCY IMPROVEMENT OF AN UNBALANCED ELECTRICAL DISTRIBUTION SYSTEM BASED ON THE CONSERVATIVE VOLTAGE REDUCTION IN TANDEM WITH THE OPTIMAL CAPACITORS PLACEMENT AND SIZING

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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 result 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.

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ABSTRACT

Energy efficiency can be achieved by means of minimizing the power losses with an adequate amount of energy utilized in an electrical distribution system. In this thesis, a detail analysis of energy efficiency of an electrical distribution system has been performed with an implementation of the conservative voltage reduction (CVR), and the optimal capacitor placement and sizing (OCPS). The differential evolution particle swarm optimization (DEPSO) is used to determine optimal location and sizing for the capacitors which in turn will improve the energy efficiency via energy consumption and power losses minimization. The pre-selection of busbar or locations is performed either based on the power-loss-index (PLI), randomly pre-selected location (RPL), or fixed pre-selected location (FPL). The DEPSO is designed based on the amalgamation of particle swarm optimization (PSO) and differential evolution (DE) that serves as a new mutation technique responsible to provide a new population with improved sizing and location of capacitors. The total cost of power losses, energy consumption and capacitor installation are the components considered in the objective and fitness functions of the proposed optimization technique. Voltage magnitude limit, total harmonic distortion (*THD*) limit, power factor limit and capacitor size limit are the parameters considered as the constraints for the proposed of optimization technique. Further improvement of energy efficiency is attained through CVR perpetrated by changing the transformer tap setting to reduce and then retain the voltage magnitude at a certain level whilst ensuring stability of the electrical distribution system. In this study, the proposed technique of DEPSO developed in MATLAB® will hand over the solution of capacitor locations, size as well as transformer tap position to the SIMULINK® software. Later, the SIMULINK® software will perform the load flow solution and pass the results to MATLAB® software to be analyzed. Effectiveness of the proposed methods used to improve the energy efficiency has been verified through several case studies and the results are obtained from the test systems of IEEE 13-bus unbalanced electrical distribution system and also the pragmatic electrical distribution system of Sultan Salahuddin Abdul Aziz Shah (SSAAS) building in Shah Alam, Selangor.

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CHAPTER ONE

INTRODUCTION

1.1 BACKGROUND AND SIGNIFICANCE OF RESEARCH

Energy is a crucial source in social and economic development of a country. In recent years, the energy consumption has been increased dramatically due to the world economic development [1]. With the increasing price of energy based petrol-fossil fuels and alternative energy sources, the economic growth of Association of Southeast Asian Nations (ASEAN) such as Singapore, Indonesia, Thailand, Vietnam, Cambodia, Myanmar and Laos are hindered. The dependency of fossil fuel as the energy source needs to be reduced in order to conserve the environment from pollution which is caused by dangerous gas emission from fossil fuel to energy conversion. The issue regarding reducing the pollution has been considered as one of the initiatives to support the Kyoto Protocol which come into force in February 2005. Albeit Malaysia did not directly involve in making the protocol, the energy and pollution issues are global where every country should take serious. ASEAN countries bring the energy issues to the Applied power Electronic Conference (APEC) where they proposed to effectively use or save the energy without causing any restraint to their economic growth. However in practical, implementation of energy saving or energy efficiency whilst sustaining the social economic growth is a very big challenge for power sector. In order to solve the energy problems faced particularly by the ASEAN, South East Asia countries including Malaysia have agreed to realize several objectives related to energy efficiency through the ASEAN Plan of Action for Energy Cooperation (APAEC) [2]. Malaysia has long been actively involved in implementing various programs and policies related to the energy efficiency which was started in 1979 under the Utilization Objective of Malaysia's Energy Policy. The sequel for those programs and policies is the National Industrial Energy Efficiency Improvement Program in 1999 which was followed by the Eighth Malaysia Plan from 2001 to 2005 [3]. In relation to that matter, the National Industrial Energy Efficiency Improvement Program was supported with huge funds contributed by the Global Environment