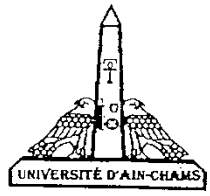

AIN SHAMS UNIVERSITY
FACULTY OF ENGINEERING
ELECTRICAL POWER AND MACHINES DEPARMENT

DISTRIBUTION SYSTEM SERVICE RESTORATION USING ARTIFICIAL INTELLIGENCE

BY

SAMAH MOHAMED TAHA EL SAFTY

B.Sc., Ain Shams University 1988
M.Sc., Ain Shams University 1993

A thesis submitted to Ain Shams University for the requirements of the degree of DOCTOR OF PHILOSOPHY
IN

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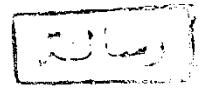
Under the Supervision

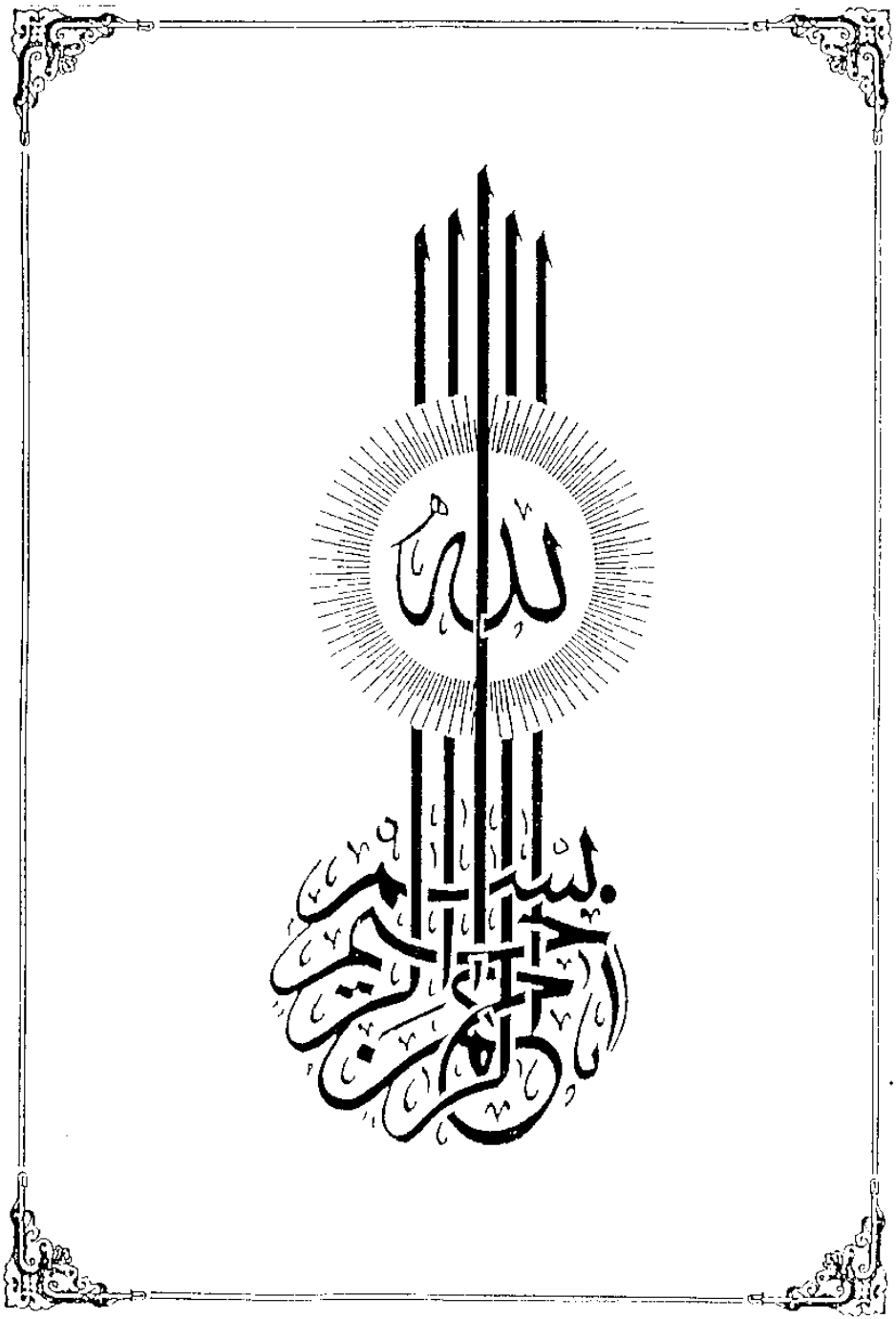


Prof. Dr. S. El Debeiky
Head of Electrical Power & Machines Dept.
Faculty of Engineering
Ain Shams University

Prof. Dr. M. M. Mansour
Electrical Power & Machines Dept.
Faculty of Engineering
Ain Shams University

Dr. H. E. A. Talaat
Electrical Power & Machines Dept.
Faculty of Engineering
Ain Shams University

Cairo-1998



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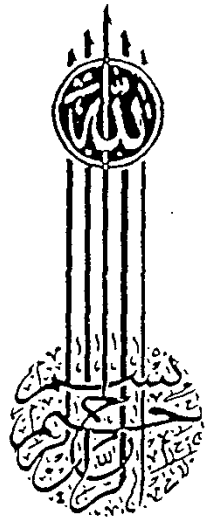

قَالُوا سُبْحَانَكَ لا عِلْمَ لَنَا إِلاَّ مَا
عَلَّمْتَنَا إِنَّكَ أَنتَ
الْعَلِيمُ الْحَكِيمُ

صدق الله العظيم
(سورة البقرة)
الآية «٣٢»

Examiners Committee

Name, Title & Affiliation — Signature

1. Prof. Dr. A. Nosseir
   Prof of Electrical Power & Machines Dept.
   Ain Shams University

2. Dr. M. M. Awad
   Deputy Chairman for Planning, Studies and Engineering
   Egyptian Electricity Authority

3. Prof. Dr. S. El Debeiky
   Head of Electrical Power & Machines Dept.
   Ain Shams University

4. Dr. H. E. D. Talaat
   Electrical Power & Machines Dept.
   Ain Shams University

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ABSTRACT

Service restoration of non-faulted out of service area after any fault is required to be performed as efficiently and quickly as possible. The restoration problem can be divided into two stages; firstly estimating system loads prior to fault and secondly devising a load restoration plan based upon estimated loads.

In this research, two artificial intelligence techniques Fuzzy Logic (FL) and Expert Systems (ES), are applied to solve the two stages of service restoration problem.

In order to restore efficiently the out of service area, knowledge of the system loads prior to fault occurrence is very important. The research addresses the problem of load estimation for restoration of distribution systems using a fuzzy reasoning approach. The approach depends on studying historical data for various load categories, then processing this data to obtain a fuzzy model for each load category. This model utilizes the knowledge of date and time of the fault to obtain the load expressed as percentage value of peak load. Knowing the main feeder current and the load categories connected to each transformer across the feeder, the value of the load at each load point is calculated. This approach is developed using Matlab.

The objectives for the restoration plan are selected so as to cope with the nature of the Egyptian distribution networks which have two principal features: they have open loop architecture and they are located

in crowded areas. Hence, a principal objective of the developed restoration plan is to minimize the number of switching operations without violating load constraints in all elements of the network while conserving the open loop structure of the network.

To achieve these requirements an ES, which contains the available system knowledge and operators' expertise is developed. The main idea of the proposed approach is to restore the out of service area on three successive stages. Firstly, the restoration using one feeder is attempted, involving a single switching operation. If any load violation is obtained, the restoration using two feeders is then attempted through three switching operations. If no available solution is obtained, the restoration using three feeders is applied through five switching operations.

The ES, which is developed using PROLOG, is investigated through a test distribution system. The results show that the proposed technique provides a valuable solution for distribution system service restoration.

The integrated approach is tested using data obtained from Cairo Distribution Company. Initially, load estimation using FL is performed. The estimated loads obtained from the fuzzy model are compared to that estimated using conventional approach. The comparison is in faith of the fuzzy load estimation. Afterwards, the developed ES is applied using the previously estimated loads to obtain an appropriate restoration plan. A successful service restoration is obtained in all case studies while minimizing number of switching operations and without any violation in loading constraints.

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