ECONOMIC LOSS OPTIMIZATION TECHNIQUE FOR DISTRIBUTION TRANSFORMER SIZING

Master of Science Dissertation

R. M. H. L.THUSHARA

Department of Electrical Engineering
University of Moratuwa, Sri Lanka

February 2011

ECONOMIC LOSS OPTIMIZATION TECHNIQUE FOR DISTRIBUTION TRANSFORMER SIZING

A dissertation submitted to the
Department of Electrical Engineering, University of Moratuwa
in partial fulfillment of the requirements for the
Degree of Master of Science

by

RAJASINGHE MADDUMA HETTIGE LASAN THUSHARA

Supervised by : Dr. Narendra de Silva
Eng. W.D.A.S. Wijayapala

Department of Electrical Engineering
University of Moratuwa, Sri Lanka

February 2011

Declaration

The work submitted in this dissertation is the result of my own investigation, except where otherwise stated.

It has not already been accepted for any degree, and is also not being concurrently submitted for any other degree.

UOM Verified Signature

R M H L Thushara
15th February 2010

We endorse the declaration by the candidate.

UOM Verified Signature

Dr. Narendra de Silva

UOM Verified Signature

Eng. W.D.A.S. Wijayapala

CONTENTS

Abstract

The Distribution system is a dynamic system which requires frequent system augmentation to ensure customer satisfaction and optimum system operation. Planning of such a system needs to consider many variables and alternative solutions in a complex process to select the system components at their economical size combination. Since distribution transformer is the major cost contributor in the secondary distribution network, correct sizing should be achieved via economical optimization in avoiding under utilization. Adoption of a global design methodology is preferred in this case.

This research was intended to implement a model based secondary distribution planning strategy which will be capable enough to provide final solution in a minimum time with economic evaluation. The application of geometry to represent distribution transformer service area is helpful in the system analysis and it simplifies greatly the complexity of the system while allowing comparison of alternative arrangements in a faster manner. Several options are analyzed during this study in comparing actual system data of large number of distribution transformers in Lanka Electricity Company's (LECO) 11kV/400V system. It is concluded that the model of hexagonal geometric service cell area with trapezoidal separation per feeder is the best fit model to represent a secondary distribution transformer service area. This selection is based of voltage oriented. This includes three main feeders originating from the distribution transformer located at the center of the hexagon.

Set of application charts for commonly available distribution transformers are developed in the research. This gives faster method of investigation about voltage drop and power loss for a particular distribution transformer in various configurations. The computer program is finally implemented in MATLAB to generate final solution for the optimum transformer capacity. Existing network expansion or reinforcement is investigated in this program. Economic optimization is implemented in both cases where Genetic Algorithm is used as an optimizing technique for the first option which achieves converged to the global optimum point in a few seconds. A detail case study is done with actual system data to verify the final results.

Acknowledgement

I wish to express my deep gratitude to my supervisors, Dr. Narendra de Siva, Head of Engineering, Lanka Electricity Company (Private) Limited, for his invaluable help in getting me started on this project, his constant guidance and sense of humor. Also thanks are due to Eng. W.D.A.S. Wijayapala, Senior Lecture, Dept. of Electrical Engineering, University of Moratuwa, for his guidance and encouragement to achieve this goal.

My sincere gratitude goes to all the department members of Electrical Engineering, Faculty of Engineering, University of Moratuwa, Sri Lanka for helping in various ways to clarify the things related to my academic works in time with excellent cooperation and guidance. Sincere gratitude is also extended to the people who serve in the Department of Electrical Engineering office.

I extend my sincere thanks to the senior management of the Lanka Electricity Company (Private) Limited where I am employed, for giving this remarkable opportunity in my career and I will not forget to thanks to the engineers in the Moratuwa Branch of Lanka Electricity company for their encouragements.

Finally, I should thank many individuals, friends and colleagues of my batch who have not been mentioned here personally in making this educational process a success. I could not have made it without your supports.

List of figures

List of tables

Abbreviations

Z_1	Impedance of the main line (Ω/km)
Z_2	Impedance of the spur line (Ω/km)
r_1	Resistance of the main line (Ω/km)
r_2	Resistance of the spur line (Ω/km)
a	Feeder length (km)
ρ	Load density (kVA/km^2)
V_L	Line voltage (kV)
TR_Capacity	Transformer capacity
R	Resistance of the transformer in p.u.
X	Resistance of the transformer in p.u.
Cosø	Power factor of the entire network in weighted average
Total_Load	Total load connected to the transformer
FC_{tx}	Fixed cost of distribution transformer
VC_{tx}	Variable cost of distribution transformer
FC_{mf}	Fixed cost of main feeders
VC_{mf}	Variable cost of main feeders
FC_{sp}	Fixed cost of spur lines
VC_{sp}	Variable cost of spur lines