



INVESTIGATION OF VOLTAGE PROFILE IN LOW VOLTAGE DISTRIBUTION NETWORK

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

By
PRABHATH CHINTHANA DEVASURENDRA

Supervised By: Prof. Ranjit Perera

Department of Electrical Engineering
University of Moratuwa, Sri Lanka

2006

86330



Abstract

Rural Electrification (RE) development constitutes construction of new substation with the capacity of 100 kVA to 160 kVA with MV feeding of 1 to 3 km. RE scheme covers one village or sometimes several villages. The Low voltage lines which are constructed along the roads in the village feeds the houses of the villagers. In the past after constructing a RE scheme, LV lines are added without considering the voltage drops even though CEB has to follow voltage regulation limits according to the Electricity Act. As a result just after the construction of RE schemes the villagers experience the voltage drops which results in not fully achieving the objectives of rural electrification. Several years ago CEB with the agreement of GOSL the lengths of LV feeder from the transformer substation was limited to 2.5 km. After a study CEB found that this length is also bigger and it causes voltage drops and Low Voltage side loses and decided to limit it to 1.8 km. This limit affect the development of rural electrification in the country because after every 1.8km feeder length, transformer substation is needed to be constructed.

There is no proper tool or method to decide the lengths of LV lines considering the consumption of the village houses. This study develops a tool to guide the Rural Electrification Engineer to decide the LV line length in RE schemes considering the consumption pattern and the consumer distribution in the village minimizing voltage drops & power loses and providing electricity to maximum number of houses of the villagers.

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.



P.C. Devasurendra

Date 01/02/2006

We/I endorse the declaration by the candidate.

UOM Verified Signature

Prof. Ranjit Perera



Contents

Declaration	i
Abstract	iii
Acknowledgement	v
List of Figures	vi
List of Tables	vii
Chapters	
1. Introduction	1
1.1 Background	1
1.2 Power Utilities in Sri Lanka	1
1.3 Expansion of Electricity	2
1.4 State Responsibility	3
1.5 Expected Social & Economic Improvements by Village Electrification	4
1.6 Problems in Rural Electrification	6
1.7 Selection of Rural Electrification Schemes	8
1.8 Evaluation Criteria Used in RE Schemes	9
1.9 Reasons for not obtaining electricity	13
1.10 Changes, which have occurred after obtaining electricity	14
2. Problem Statement	15
2.1 Preliminaries	15
2.2 Problem Identification	17
2.3 Other Related	19
3. Proposed Solution	20
3.1 Methods and Techniques	20
4. Theoretical Developments	29
4.1 Basic Theory of The Analysis	29
4.2 Mathematical Derivations	30
4.2.1 Trapezoidal consumer distribution pattern	31
4.2.2 Rectangular consumer distribution pattern	34
4.2.3 Triangular consumer distribution pattern	36
5. Application of the Proposed Method	37
5.1 Applications	37

6. Results and Analysis	40
7. Conclusions	57
References	59
Appendices	60
Appendix A Programs	60
Appendix B Distribution Layout of an RE Scheme	67

Acknowledgement

Thanks are due first to my supervisor, Professor Ranjit Perera, Head of the Department of Electrical Engineering, for his great insights, perspectives, guidance and sense of humor. My sincere thanks go to Dr Wijekoon Banda, Planning Branch, Ceylon Electricity Board and Mr Bogahawatta, Chief Engineer, Ceylon Electricity Board, for helping in various ways to clarify the things related to my academic work with excellent cooperation and guidance. Sincere gratitude is also extended to Electrical Superintendents in several customer service centers (CSC) of CEB, for providing me necessary data. Lastly, I should thank many individuals, friends and colleagues who have not been mentioned here personally in making this educational process a success.

List of Figures

	Figure Page
1.1 Graphical Representation of Increase of Electrified Households	12
1.2 Electrified Households	12
2.1 A typical RE scheme	15
2.2 General Arrangement at a Distribution Substation	16
3.1 Scheme Layout Sketch	22
3.2a Simple representation of the feeder	23
3.2b The connection pattern of loading of houses to the feeder	23
3.2c The approximated connection pattern	24
3.2d Trapezoidal distribution pattern	25
3.3 Algorhythm-1	27
3.4 Algorhythm-2	28
4.1 A line-to-neutral equivalent circuit	29
4.2 Phasor Diagram	29
4.3 Trapezoidal consumer distribution pattern	31
4.4 Rectangular consumer distribution pattern	34
4.5 Triangular consumer distribution pattern	36
5.1 Sketch of a Proposed Scheme	38
6.1 Plot of Feeder-1 Loading Between Poles Vs Length of Feeder	42
6.2 Plot of Feeder-1 Loading with an Approximation	42
6.3 Approximation Plot of Loading of Feeder-1	43
6.4 Sectionalized Plot of Feeder-1	43
6.5 Plot of Feeder-1 Branch-1 Loading	45
6.6 Plot of Feeder-1 Branch-1 Loading with an Approximation	45
6.7 Approximation Plot of Loading of Feeder-1 Branch-1	46
6.8 Sectionalized Plot of Feeder-1Branch-1	46
6.9 Plot of Feeder-1Branch-2 Loading	47
6.10 Plot of Feeder-1Branch-1 Loading with an Approximation	48
6.11 Approximation Plot of Loading of Feeder-1 Branch-2	48
6.12 Sectionalized Plot of Feeder-1Branch-2	49
6.13 User Interface of The Programme	51
6.14 Display of Input Data for Feeder-1	51
6.15 Display of calculated Voltage drop & Power loss for Feeder-1	52
6.16 Voltage Drop Variation For Feeder-1	52
6.17 Display of Input Data for Feeder-1Branch-1	53
6.18 Display of calculated Voltage drop & Power loss for Feeder-1Branch-1	53
6.19 Voltage Drop Variation For Feeder-1Branch-1	54
6.20 Display of Input Data for Feeder-1Branch-2	54
6.21 Display of calculated Voltage drop & Power loss for Feeder-1Branch-2	55
6.22 Voltage Drop Variation For Feeder-1Branch-2	55

List of Tables

	Table Page
1.1 Percentage Electrification Level (By Districts)	2
1.2 Rural Electrification Projects	4
1.3 Rural Electrification Programme (1998 – 2005)	11
5.1 Sample Data Table	39
6.1 The data of the feeder-1 of Maha Ingiriya Substation	41
6.2 Results of Feeder-1 from Sectionalized Plot of Feeder-1	44
6.3 Results of Feeder-1 Branch-1 from Sectionalized Plot of Feeder-1 Branch-1	47
6.4 Results of Feeder-1 Branch-2 from Sectionalized Plot of Feeder-1 Branch-2	50
6.5 Comparison of Results of Two Methods	56

