MITIGATION OF IMPACTS OF LIGHTNING SURGES ON LOW VOLTAGE SIDE OF POWER DISTRIBUTION SUBSTATIONS

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Degree of Master of Science in Electrical Engineering

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DECLARATION OF THE CANDIDATE AND SUPERVISORS

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The above candidate has carried out research for the Masters Dissertation under my supervision.

……...	……...
Signature of the supervisor	Date
(Prof. J.R. Lucas)	

ACKNOWLEDGEMENTS

First of all, my gratitude is towards my supervisor, Professor J. R. Lucas, who guided me throughout my research work, in spite of his busy schedules.

Also, I would like to extend my gratitude to all the lecturers of Electrical Engineering Department, University of Moratuwa for the guidance provided by them to improve my research, with their valuable comments.

My gratitude also given towards former Deputy General Manager Eng. K.M.K. Perera, Deputy General Manager Eng. R.A.A.S. Seneviratne, Deputy General Manager Eng. N.W. Kumarasingha, and Chief Engineer R.K.P.S. Gunathilake of Ceylon Electricity Board for all the support given to me to complete my research successfully.

I would also like to appreciate my colleagues E.A.E.H. Hemachandra, D.M.D.K. Dissanayake, J.G.S Nalani for the motivation given to me to complete my research work. Also, I would like to thank the members of Energy Management Team of DD3, CEB for their tireless efforts in the field to implement this project.

Finally, I owe my gratitude to my parents, my wife and my little daughter for their endless support and encouragement and without them I would not have come this far.

ABSTRACT

Lightning surges are the major source that causes failure of power electronic equipment in low voltage (LV) power distribution systems, specially for the equipment with low immunity parameters and high sensitivity to surges. The 400/230V low voltage systems are usually affected by lightning mainly by the surges coming through the distribution transformers. In addition to that induced surges or direct strikes on load side could cause damage to distribution substations.

Power utilities are concerned about the possibility of damage to distribution transformers caused by lightning strikes leading power supply failures and other losses including transformer damage, meter equipment damage and damage to the surroundings. Assessment of such occurrences is important in the design of suitable protection schemes and mitigation strategies. The number of incoming surges, their energy content as well as the number and the amplitude of power frequency follow currents determine the level of protection required for each substation. Hence, the assessment of impacts becomes more and more important for the design of lightning protection system.

The methods used in Sri Lanka to assess the impacts of lightning are based on experience of the utility employees or the frequency of protection failures and power supply failures. Specially, when it comes to the low voltage (LV) side, the impacts are not assessed or examined, and in most of the cases, the low voltage side of a substation is not effectively protected from lightning.

In this research the impact of lightning surges particularly on low voltage side of the power distribution substation was analyzed, and the possibilities of using protection mechanism in low voltage side of the power distribution substations were investigated in order to reduce or avoid human and installation damage caused by lightning. Study was limited to power distribution substations in the service area of Distribution Licensee No. 3 (Distribution Division 3 of Ceylon Electricity Board) where the total number of installed distribution substations were around 5000.

Then by simulating the impact of lightning surges on a low voltage side of power distribution substation using PSCAD software, the behavior of the electrical parameters under occurrence of lightning was studied, and based on the observations and results, design parameters for the protection system were derived.

Then the available protection methods for low voltage systems in the world were studied. In the next stage, to protect the low voltage side of the distribution substation economically and safely, application of several protection systems was investigated. Those protection systems included surge protective devices (SPD) and proper grounding mechanisms tried out on LV side of the selected distribution substations of DD3.

Finally, based on the findings of investigation, simulation and pilot installation, a standard protection system was deployed, and results were analyzed to check whether the implemented protection system was effective in electrical terms and monetary terms. Continuous monitoring of protected distribution substations has been carried out and the results were produced in the report.

By the results of the assessment of the impacts of lightning on LV side of power distribution substations, it was obvious that huge amount of visible and invisible losses is incurred to Ceylon Electricity Board. The results of the PSCAD simulation clearly shows that the LV side of the power distribution side is affected in the event of lightning strikes. Hence, it was concluded that the LV side of the power distribution side should be protected to eliminate the impacts of lightning strikes. Finally, this research proposes a standard protection mechanism to protect distribution substations from lightning and the effectiveness of the protection system was proved by the results obtained.

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ABBREVIATIONS

CEB	Ceylon Electricity Board
DD3	Distribution Division 3
kVA	kilovolt Ampere
kW	kilo Watt
kWh	kilo Watt hour
LV	Low Voltage
MV	Medium Voltage
HV	High Voltage
HT	High Tension
LT	Low Tension
PDS	Power Distribution Substation
DT	Distribution Transformer
SPD	Surge Protection Device
I_n	Nominal Discharge Current
I_{imp}	Impulse current
U_c	Continuous Operating Voltage
U_p	Protection Voltage
BIL	Basic Insulation Level
ac	Alternating Current
PPM	Programmable Polyphase Meter
TDT	Time of Day Tariff
CT	Current Transformer
MOV	Metal oxide varistor