A POWER SUPPLY RELIABILITY ASSESSMENT MODEL FOR THE COLOMBO SUBURBAN RAILWAY NETWORK

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Degree of Master of Science

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August 2020

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Thesis/Dissertation submitted in partial fulfilment of the requirements for the degree
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DECLARATION

I declare that this is my own work and this thesis does not incorporate without acknowledgement any material previously submitted for a Degree or Diploma in any other University or institute of higher learning and to the best of my knowledge and belief it does not contain any material previously published or written by another person except where the acknowledgement is made in the text.

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Signature of the supervisors: Date:

Prof. Ranjith Perera

Signature of the supervisors: Date:

Dr. Tilak Siyambalapitiya

DEDICATION

I dedicate my M.Sc. research dissertation to my beloved parents and my wife for their guidance given throughout my life.

ACKNOWLEDGMENT

I would like to sincerely thank my internal supervisor, Prof. Ranjith Perera, Department of Electrical Engineering, University of Moratuwa for the continuous support, encouragement and expertise in the field to make this Masters research a success.

I am really grateful to supervisor, Dr. Tilak Siyambalapitiya, Managing Director, Resource Management Associates (Pvt) Ltd. for being the originator of this research idea and for the guidance given to me to make this research a success.

I would like to thank the postgraduate research coordinator of department, Dr. Darshana Prasad for the supervision and management of research evaluation. I would like to a pay my sincere appreciation to the academic staff of the Department of Electrical Engineering for their valuable feedback and constructive comments during progress reviews.

I would like to sincerely thank Eng. (Ms.) H.D.K. Herath, Electrical Engineer, Transmission Planning, Ceylon Electricity Board and Eng. (Ms.) Thotagamuwage Sajani, Junior Electrical Engineer, Colombo Suburban Railway Project for providing continuous support to get the required details for the project. I pay my special gratitude to Dr. H.M. Wijekoon Banda, Chief Engineer Transmission Planning, Ceylon Electricity Board and Eng. U.N. Sanjaya, Electrical Engineer, Transmission Planning, Ceylon Electricity Board for their support and guidance.

My heartfelt gratitude shall go to my family and friends who had been caring, supporting and facilitating me throughout the work.

ABSTRACT

An electrified railway network is one of the solutions for Colombo traffic congestion due to high population density and high daily passenger flow into the city from the suburbs. Although the initial cost of a railway electrification project is higher compared with other alternatives such as improvements to bus transport, energy, maintenance and operational costs can be lower if the system is designed, maintained effectively and used efficiently. System failures or, delays in system operations should be minimized to reduce the time wasted in traveling.

Reliability and punctuality are the major factors to attract more passengers to use public electrified transport facilities for their daily travel. Power supply is a critical factor to maintain a higher reliability in an electrified railway system.

Designs to upgrade the 230 km long Colombo suburban railway network commenced in 2017 and currently in progress in four stages. Different options for the power supply configuration and the back-up power systems have been identified, qualitatively evaluated and then recommended for implementation. A quantified reliability assessment has not been reported in the design.

A standardized procedure and a reliability assessment model would be required to evaluate the reliability of each optional configuration to supply power and backup power. In this research, optional configurations to supply power to the future electrified railway system of the Colombo Suburban Railway Project area were developed. Reliability assessment was conducted for each optional configuration using the models developed and simulated using Monte Carlo simulation technique. Reliability worth analysis was done to weigh the costs and benefits of configurations with higher reliability.

The model developed can be used for reliability assessment of the power supply to any suburban electrified railway system in Sri Lanka.

Keywords: Electrified Railway, Monte Carlo simulation, Reliability Assessment Model, Reliability Worth

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List of Abbreviations

Abbreviation	Description
AC	Alternative Current
BB	Bus Bar
CB	Circuit Breaker
CEB	Ceylon Electricity Board
CMR	Colombo Metropolitan Region
CSRN	Colombo Suburban Railway Network
CSRP	Colombo Suburban Railway Project
CT	Current Transformer
CVT	Capacitive Voltage Transformer
DMU	Diesel Multiple Unit
ET	Earthing Transformer
EDNS	Expected Demand Not Supplied
EENS	Expected Energy Not Supplied
EMU	Electric Multiple Unit
ES	Earth Switch
ETF	Earthing Transformer
FTA	Fault Tree Analysis
G&T	Generation and Transmission
GSS	Grid Sub Station
HL	Hierarchical Levels
HV	High Voltage
IEC	International Electro technical Commission
IEEE	Institute of Electrical and Electronic Engineering
ISO	Isolator
KV	Kelani Valley
LA	Lightning Arrester
LCC	Life Cycle Cost
LOLF	Loss of Load Frequency

LOLP	Loss of Load Probability
LV	Low Voltage
MCS	Monte Carlo simulation
MTTR	Mean Time to Repair
MV	Medium Voltage
NCRE	Non-Conventional Renewable Energy
NCT	Neutral Current Transformer
O&M	Operation and Maintenance
OCS	Overhead Contact System
PPTA	Project Preparatory Technical Assistance
RSI	Railway System Index
SCADA	Supervisory Control and Data Acquisition
SCC	System Control Centre
SL	Sri Lanka
TSS	Traction Substation
VT	Voltage Transformer