

**SYSTEM IMPROVEMENT THROUGH CO-ORDINATED  
RING CIRCUIT IN MEDIUM VOLTAGE NETWORK IN  
COLOMBO CITY: A CASE STUDY**

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Degree of Master of Science

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## **DECLARATION PAGE OF THE CANDIDATE & SUPERVISOR**

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## **ABSTRACT**

Power distribution systems feed in radial and ring feeding mechanisms. The radial feeding arrangement is used in rural networks where reliability is very low. In urban areas, ring feeding arrangements are likely to be used which provides an alternative feeding arrangement for load.

Colombo City uses an open loop feeding arrangement with a normally open point in the ring arrangement. It has an underground 11kV network where panel substations in a ring (partly meshed) manner are connected around the primary substation. Outgoing feeders from these panel substations are again connected in a ring manner through Ring Main Units.

By providing correct directional protection coordination these panel substations can be operated in a closed loop ring arrangement to improve reliability. It will also reduce distribution line losses and improve the system voltage profile.

In my dissertation, area fed by Primary Substation F was taken into consideration for analysis. Different time zones were recognized based on load changes for week days and weekends. The possible ring arrangements were identified and load flow analysis was carried out using SynerGEE for radial and closed loop ring arrangement to detail the power loss reduction, voltage improvement, excessive active power and reactive power absorbed by loads.

Reliability improvement was derived for SAIFI and SAIDI, using the rate of failure of cables based on the cable failure details of Colombo City. Voltage analysis and cost analysis were also carried out using SynerGEE.

Directional protection coordination was derived for two feeders operating in closed loop, two substations operating in closed loop and three substations operating in closed loop to cover the identified paralleling patterns in selected zones. Based on fault levels and the cable impedance data protection settings were calculated for actual field conditions for each pattern. Each pattern was simulated in Matlab to monitor the voltage and current variations for cable faults.

In conclusion, if the conditions prevail, the panel arrangement existing in Colombo City provides an easy approach to operate the system in a closed loop ring arrangement by replacing existing numerical relays with directional numerical relays, which improves the reliability, reduces the distribution losses and provides voltage improvements.

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## LIST OF ABBREVIATIONS

<b>Abbreviation</b>	<b>Description</b>
MV	Medium Voltage
NOP	Normal Open Point
LBS	Load Break Switch
RMU	Ring Main Unit
HV	High Voltage
CEB	Ceylon Electricity Board
SAIFI	System Average Interruption Frequency Index
SAIDI	System Average Interruption Duration Index
CC	Colombo City
PSSF	Primary Substation F
LV	Low Voltage
PILC	Paper Insulated Lead Covered
XLPE	Cross Linked Poly-Ethylene
CCCC	Colombo City Control Centre
IDMT	Inverse Definite Minimum Time
SCADA	Supervisory Control and Data Acquisition
CCDDP	Colombo City Electricity Distribution Project
AVR	Automatic Voltage Regulator
PSM	Pickup Setting Multiplier
TSM	Time Setting Multiplier
FL	Fault Level
OC	Over Current
EF	Earth Fault
SI	Source Impedance
P	Primary Substation
R	Radial/Ring Substation
F	Feeder
BS	Bus Section
Ld	Load feeder
$z$	Impedance of the cable
$Z$	Impedance

V	Medium Voltage Level (11kV)
$I_{FL}$	Fault Current
CB	Circuit Breaker
DT	Definite Time