

**INSULATION COORDINATION OF QUADRUPLE CIRCUIT HIGH
VOLTAGE TRANSMISSION LINES USING ATP-EMTP**

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To my beloved husband and dear children, who are always giving their support and understanding. They are always with me when I need support and advice and without their understanding, I will not be able to complete my master study

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ABSTRACT

A significant number of faults in overhead transmission lines are due to lightning strikes which cause back flashovers and hence single or double circuit outages. The continuity and quality of the power supply is therefore can be severely affected by the outages, especially in Malaysia where the isokeraunic level is rather high. The lightning performance of transmission lines is also influenced by the transmission line configuration itself. In Malaysia, the TNB's transmission lines consist of 500 kV or 275 kV double circuits, and 275/132 kV quadruple circuits. It is known that the lower portion of the 132 kV line apparently has the lowest lightning performance.

The application of transmission line arresters is also known to be the best method in improving the lightning performance of transmission lines in service. However, its usage requires proper coordination and placement strategy to ensure optimum improvement in lightning performance.

In this work, the ATP-EMTP simulation program was used to study the lightning performance of the quadruple circuit transmission line behaviour towards lightning activities. The models used include those for the surge arresters, overhead lines, towers and insulators. All models were based on the data supplied by the utility. Initial results show that the configuration 6 gives the best protection or lowest flashover rate.

ABSTRAK

Kebanyakan gangguan bekalan pada talian atas penghantaran adalah disebabkan oleh panahan petir yang mana telah mengakibatkan kerosakkan dan gangguan bekalan pada litar sedioda dan litar berkembar. Gangguan bekalan ini telah mengakibatkan keterusan dan kualiti bekalan elektrik terganggu teruk. Tahap panahan petir di talian atas penghantaran adalah juga dipengaruhi oleh konfigurasi talian atas itu sendiri. Di Malaysia, talian penghantaran TNB adalah terdiri dari 500kV atau 275kV litar berkembar dan 275/132kV litar berkembar empat(quadruple circuits). Telah dikenalpasti bahawa pada bahagian bawah talian 132kV adalah merupakan tahap panahan petir yang terendah.

Penggunaan penangkap kilat untuk talian atas adalah merupakan cara terbaik dalam memperbaiki tahap panahan petir di talian atas yang sedang beroperasi. Walau bagaimanapun, penggunaanya memerlukan koordinasi yang tepat dan lokasi yang strategik bagi mendapatkan kesan yang optimum.

Untuk kajian ini, aturcara simulasi ATP-EMTP telah digunakan bagi mengkaji tahap dan aktiviti panahan petir terhadap litar berkembar empat. Model yang digunakan adalah termasuk penangkap kilat, talian atas penghantaran, menara dan penebat. Semua data yang digunakan untuk dimodelkan adalah diperolehi dari pembekal elektrik Keputusan dari simulasi yang dibuat menunjukkan konfigurasi 6 telah menghasilkan perlindungan yang terbaik dan kadar gangguan bekalan yang terendah

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CHAPTER 1

INTRODUCTION

1.1 Background

Transmission system in services can be divided into two which are overhead transmission system and cable type transmission system. The main focus here is the overhead transmission systems, which are directly subjected to lightning over voltage. A significant number of the faults on overhead transmission lines are due to lightning. Lightning Faults may be single or multiple, and their elimination causes voltage dips and outages. Therefore, the outage rate of a line and the quality of the delivered voltage depend on the lightning performance of the line.

Many procedures have been presented over the years with the aim of predicting the lightning performance of transmission lines. Modern understanding about lightning phenomena and lightning attraction mechanisms allowed developing methods for estimating the lightning performance of overhead lines which avoid such empiricism.

For this purpose, the performance of transmission lines is estimated using ATP-EMTP simulation programs

1.2 The Objectives of the Research

The main objective of the project is to improve the lightning performance of transmission lines by the application of line surge arresters on the quadruple circuit transmission line and to analyze different line surge arresters application configurations in order to optimize application of this technology to the existing and to the future quadruple transmission lines.

1.3 Scope of Study

The main scope of this project is to study the applications of surge arresters on transmission line to improve the lightning and transient performance of the transmission line which is includes:

- Arrangement of line arresters for optimum technical and economic
- Performance which include where or which tower along the line arresters to be installed
- The rating and withstand energy of the surge arresters
- The arresters configurations

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LIST OF ABBREVIATIONS

ac	-	Alternating Current
ACSR	-	Aluminium Conductor Steel Reinforced
AIS	-	Air Insulated Substation
ATP	-	Alternative Transient Program
BFR	-	Back Flashover Rate
BIL	-	Basic Lightning Insulation Level
CB	-	Circuit Breaker
CBPS	-	Connaught Bridge Power Station
CFO	-	Critical Flashover
EMTP	-	Electro Magnetic Transient Program
FDQ	-	Frequency Dependent Q Matrix
GIS	-	Gas Insulated Substation
GPS	-	Global Positioning System
IEE	-	The Institution of Electrical Engineers
IEEE	-	Institute of Electrical and Electronic Engineers
IVAT	-	High Voltage and Current Institute
LOC	-	Leader Onset Conditions
MO	-	Metal Oxide
MOV	-	Metal Oxide Varistor
OPGW	-	Optical Fibre Composite Ground Wire
SA	-	Surge Arresters
SiC	-	Silicon Carbide
S/S	-	Substation

TFR	-	Tower Footing Resistance
TLA	-	Transmission Line Arresters
TNB	-	Tenaga Nasional Berhad
ZnO	-	Zinc Oxide

LIST OF PRINCIPLE SYMBOLS

μF	-	micro-Farad
μH	-	micro-Hendry
μs	-	nicro-second
A	-	Ampere
C	-	Capacitive
N_g	-	Ground Flash Density per Kilometer² per year
kA	-	kilo-Ampere
kJ	-	kilo-Joule
kV	-	kilo-Volt
L	-	Inductive
MV	-	Mega-Volt
R	-	Resistance
U_c	-	Maximum Continuous Operating Voltage
U_r	-	Rated Surge Arrester Voltage
Km	-	kilometer
V	-	Volt
Z	-	Impedance
Z_t	-	Surge Impedance