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

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A thesis submitted in partial fulfillment of the requirements for the award of the degree of Master of Engineering (Electrical-Power)

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MEI 2007

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

ACKNOWLEDGEMENT

I would like to express my sincere appreciation and special thanks to my project supervisor, Prof. Dr. Zulkurnain Abdul Malek, for his support, advices, encouragement, guidance and friendship. I wish to thank the grateful individuals from TNB research and TNB Generation. I am grateful for their cooperation and willingness to assist me in this matter.

I am also would like to thank all my friends especially Adzhar Bin Khalid for their assistance towards the successful completion of this project. I am also indebted to Universiti Teknologi Malaysia (UTM) for their assistance in supplying the relevant literatures.

Last but not least, I wish to thank my beloved husband, Surmazalan B. Ngarif who give me his undivided attention and support throughout this research.

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

Kebanyakkan gangguan bekalan pada talian atas penghantaraan adalah disebabkan oleh panahan petir yang mana telah mengakibatkan kerosakkan dan gangguan bekalan pada litar sediada 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 configurasi 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 penghantaraan, menara dan penebat. Semua data yang digunakan untuk dimodelkan adalah diperolehi dari pembekal elektrik Keputusan dari simulasi yang dibuat menunjukkan configurasi 6 telah menghasilkan perlindungan yang terbaik dan kadar gangguan bekalan yang terendah

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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 Kilometer^2 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**