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Implementation and Use of Multi Chamber Arresters for 33kV Overhead Lines in Malaysia

Noradlina Abdullah
Lightning & Earthing Unit
TNB Research Sdn Bhd
Selangor, Malaysia
noradlina.abdullah@tnb.com.my

Miszaina Osman
Institute of Power Enginering (IPE)
Universiti Tenaga Nasional
Selangor, Malaysia
miszaina@uniten.edu.my

Mohd Zainal Abidin Abd Kadir
Institute of Power Engineering (IPE),
Universiti Tenaga Nasional
Selangor, Malaysia
zainal@uniten.edu.my

Norhasliza Mohd Hatta
Lightning & Earthing Unit
TNB Research Sdn Bhd
Selangor, Malaysia
norhasliza.hatta@tnb.com.my

Mohd Faris Ariffin
Asset Management Strategy & Design
Standards Distribution Network,
Tenaga Nasional Berhad, Malaysia
farisar@tnb.com.my

Abstract— Multi chambers arresters were installed on 33kV bare overhead line in Malaysia to improve the line trippings due to lightning. In this pilot study, the line was equipped with line fault indicators and auto recloser for transient event recording. Field monitoring was carried out to determine feasibility and reliability of the device in preventing line trippings due to lightning. The case study line has been experiencing a significant amount of lightning activities, a total of 1,805 lightning strikes, detected by TNBR Lightning Detection System during 6 months monitoring period with an average peak current of 18.61 kA. Observation of one-time indicators has shown that 31 out of 180 devices have operated during the monitoring period. Line lightning performance analysis was carried out to quantify the effectiveness of the device in reducing tripping rate.

Keywords—multi chamber arresters, distribution lines, lightning performance

I. Introduction

This pilot study focuses on the use of new line surge arrester technology for the improvement of 33kV line lightning performance in Tenaga Nasional Berhad (TNB), Malaysia. This initiative is part of TNB Pole Performance Enhancement Program which seeks for long term and efficient solutions for medium voltage overhead lines (MV OHL) lightning protection issues. MV OHL that cut across open areas, i.e., with no natural shielding are subjected to frequent direct lightning strikes based on the observation from local Lightning Detection System Network (LDSN) operated by TNB Research (TNBR).

Currently, the lightning protection installed on MV OHL is using metal oxide varistors (MOV) Line Surge Arrester (LSA) Class II, as recommended by IEEE 1410 [1]. The MOV LSA contains metal oxide varistors blocks where its primary function is to suppress overvoltages and prevent flashovers at the instant of lightning strikes. This device should be able to cut off follow current from lightning arc before the circuit breaker operates. It does not operate under switching overvoltages and does not cause a permanent fault. Normally, the MOV LSA requires low earthing resistance to discharge surges effectively to earth.

Low earthing resistance helps in improving the line lightning performance and ensuring the MOV LSA operates according to its design specification and its intended lifetime. The lifetime of this type of LSA will be affected whenever it is installed at high earthing resistance areas (which is normally occur at high soil resistivity areas).

A multi chamber arresters (MCA) is based on long arc flashover concept without MOV is a potential solution for improving line lightning performance for poles located in areas with high resistivity soils and high intensity & frequency of lightning activities. The device concept and technology have been elaborated in references 2-5. It consists of a large number of electrodes mounted on a silicon rubber shape frame (i.e., one electrode by a discharge chamber).

This system helps to divide a large power (arc occurring in case of lightning overvoltage) in a large number of small arcs existing in fairly small discharge chamber formed by two adjacent electrodes. The high pressure appearing in the discharge chambers (by a combination of the extremely high temperature of the arc and small size of chambers) blows the arc out to the ambient air and thereby quench the arc (in a max of 10msec). With this mechanism of discharging arc through air, there is no need for any earthing connection to ground and thus it is an attractive option for areas with high earthing resistance that is too costly for further improvement (i.e. reducing earthing resistance to increase line lightning performance of the line).

II. Methodology

A. Case Study Site Selection

For this pilot project, a case study line was selected based on the following criteria: (a) bare 33kV medium voltage distribution overhead lines, (b) the line has historical records of frequent tripping incidents due to lightning, (c) the line has a high lightning activity profile based on data collected from Lightning Detection System Network TNBR., and (d)

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the line is located within areas with medium to high soil resistivity values.

Sampling of earthing resistance of poles and soil resistivity values were carried out prior to final selection. A 16-km length of case study line running though high resistivity soils with high pole footing resistances located at the Northern State in the Peninsular Malaysia was selected for this technology assessment. The study line has high frequency of transient occurrences due to lightning based on the historical records since 2015. For the period of 1.3 years, the line has experienced a total of 33 trippings due to lightning i.e. flashover rate of 152.46 per 100 km per year Lightning density map for the line is shown in Fig. 1.

B. *Optimized Device Placement*

The optimized placement of each MCA was based on simulation using EMTP-RV which only focus on direct lightning impacts on the case study line lightning performance estimation. The procedure in estimating the number of direct flashovers for the distribution overhead line follows IEEE 1410 [1]. The MCAs were installed on all

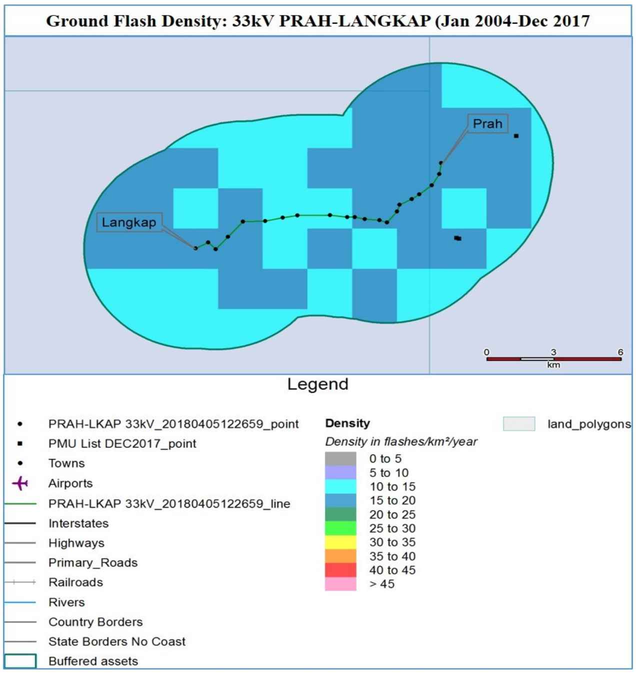

Fig. 1. Lightning Ground Flash Density for case study line (2004 – 2017)

phases of each poles (i.e. 3 units per poles) which deemed as optimized placement from the simulation to reduce the flashover rate to 0.6 per 100km per year. The line was equipped with four sets of line fault recorders at selected sections. The line performance was monitored for 6 months (June 2016 until December 2017) by comparing the faults/transients detected with the lightning activities occurrences recorded within line vicinity.

III. Results & Discussions

A. *Site Measurement Results*

In order to determine the suitability of the case study line for the MCSA application, poles earthing resistances and soil resistivity values were measured using Fall of Potential measurement method and soil resistivity measurement (Wenner array), respectively [6] . Poles are located at considerably high soil resistivity area (top/middle layer > 200Ωm) with earthing resistance values >15Ω. Majority of poles are located at open areas (no natural shielding i.e. trees) whereby direct lightning strikes probability is high. Summary of measurement soil resistivity and earthing resistances are given in Table I.

TABLE I. Summary of Soil Resistivity and Earthing Resistance for Case Study Line

No.	Pole No.	*Soil Type	TFR (Ω)	Layer 1		Layer 2	
				ρ (Ωm)	*Depth (m)*	*ρ (Ωm)*	*Depth (m)*
1	12	Sandy	522.00	1520.57	2.11	36.2	∞
2	34	Clay	64.35	71.71	1.96	413.1	4.68
3	43	Clay	25.30	261.91	1.96	850.9	5.05
4	79	Sandy	59.70	5291.60	3.16	265.6	∞
5	90	Loamy	97.90	706.40	1.41	79.4	1.33
6	110	Loamy	100.2	859.85	0.81	1628.6	2.69

a. Note: * soil types for each site are based on visual observation only.

B. *Field Observations*

The case study line has been experiencing a significant amount of lightning activities occurring within line vicinity. Statistics of lightning activities detected by TNBR Lightning Detection System Network has recorded a total of 1,805 lightning strikes during 6 months monitoring period with average peak current of 18.61kA as shown in Table II. Observation of one-time indicators has shown that 31 out of 180 devices have operated during the monitoring period from 1st June 2016 until 31st December 2016.

TABLE II. Statistics of Lightning Activities within Line Vicinity (June – Dec 2016)

Month	Count	Min Peak Current (kA)	Max Peak Current (kA)	Average Peak Current (kA)
June	22	3.20	52.50	14.45
July	451	3.35	97.40	20.24
August	207	5.18	86.95	18.43
September	52	6.09	75.52	19.49
October	39	6.05	54.83	16.29
November	716	4.13	178.21	20.96
December	318	3.83	91.21	20.40

Line lightning performance analysis was carried out to quantify the effectiveness of the device in reducing tripping rate. Tripping before the installation (June 2015 to March 2016) recorded 33 events (i.e. 152.6 flashovers per 100-km per year) compared to tripping after installation (June 2016 – March 2017) with 3 events (i.e. 28.07 flashovers per 100-km per year) as shown in Table III.

TABLE III. Auto Recloser Events Recorded on Study Line after Installation

No.	Date	Time	Ph a (A)	Ph b (A)	Ph c (A)	n (A)	Fault Type
1	16/07/2016	15:31:57.867	5747	6223	5833	8	pppg
2	07/10/2016	2:20:15	1012	88	93	943	pg
3	10/10/2016	9:34:55	1502	1487	71	0.183	ppg

A reduction of 90.9% tripping rate due to lightning after the installation of the MCA on the line was observed. The multi chamber arresterss were able to reduce transient trippings due to lightning where MOV LSA is unable to do so at high soil resistivity area (and high pole earthing resistance) of this line.

IV. Conclusions

In this study, the review of new multi chamber arresters technology concept, required equipment and accessories, and the specific requirement for installation on bare MV overhead lines was carried out. Pilot installation of 160 units and performance evaluation were carried out on 33kV bare overhead line which has high soil resistivity profiles and experienced frequent trippings due to lightning.

Line lightning performance analysis was carried out to determine quantitatively the effectiveness of the device in reducing the line tripping rate. A reduction by 90.9% in line lightning tripping rate after installation was observed. This initiative has significantly reduced the number of tripping incidences due to lightning and improved the performance of the line. The use of the new line lightning protection technology is a possible long-term and effective solution for 33kV overhead line protection against direct lightning strokes.

V. References

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