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Transmission-Lightning-Arrester : A Location Determination Using Tflash

M. I. Jambak2, M. A. B. Sidik1,2, Z. Buntat*1, Z. Nawawi2, R.F. Kurnia2, Y. Z. Arief1, A. A. Wahab3, Z. Ramli3, M. E. Ramly3
[1]Institute of High Voltage and High Current, and Faculty of Electrical Engineering
Universiti Teknologi Malaysia, UTM Johor Bahru, Johor, Malaysia
2Department of Electrical Engineering, Faculty of Engineering
Universitas Sriwijaya, South Sumatera, Indonesia
3Tenaga Nasional Berhad, Malaysia
*Corresponding author's email: zolkafle@fke.utm.my

Abstract—**The high density of lightning occurrence in Malaysia has caused problems to transmission and distribution electrical energy. Normally, transmission overhead lines trip due to Back Flashover (BF) of lightning and shielding failures of earth wire. Therefore, a detailed lightning study is required to analyse the corresponding lines and to determine the exact location of Transmission Lightning Arrester (TLA). In this paper, a simulation of lightning study using TFlash software associated with the installation of (TLA) at 132 kV SSWW-BBST overhead lines system located in Selangor, Malaysia is presented. By using the TFlash software the location of TLA has been determined.**

Keywords – Overhead transmission line, transmission Lightning arrester, lines performance, lightning protection.

Introduction

Lightning strikes to overhead transmission lines (OHTL) are one of the major contributors of unscheduled supply interruptions and power system tripping. It caused a lot of damage electrical equipments in Tenaga Nasional Berhad (TNB) power system [1]. Predicted about fifty to sixty percent of trippings in TNB's power system, especially on transmission and distribution networks have been caused by the lightning [2]. In order to reduce the number of trippings TNB has been conducting numerous measures and research to ensure the reliability and sustainability of electrical power supply [3]. Several methods have been proposed to keep failure rates in a low level as well as to avoid damages and disturbances to the OHTL system. The methods such as improving tower footing resistance, installing earth wires, and transmission lightning arresters (TLA) installation [4-6].

Based on reports of various electrical utilities, TLA installation at OHTL's towers is the most efficient method compared the others in improving the OHTL performance. However, due to the economic consideration, installation of TLA at every conductor of OHTL is absolutely impractical. This paper presents an analysis of OHTL performance and determination of TLA optimum quantity applied in 132 kV Sungai Semenyih Water Works towards Bandar Baru Salak Tinggi (SSWT-BBST).

Overhead Lines 132 KV SSWT-BBST brief description

The 132 kV SSSW-BBST OHTL system is located at area of Selangor, Malaysia. It consists of 55 (fifty five) numbers of tower – mostly through hilly terrain – with double circuit of 132 kV rated voltage. Commissioned on August 14, 2007 for Line 1 and August 15, 2007 for Line 2, the phase conductors used for OHTL are 2 x 300 mmsq Aluminum Conductor Steel Reinforced (ACSR Batang) with a route length of approximately of 14.7 km

A) Geographic profile

All tower locations were plotted on Google earth to delineate the OHTL end to end as shown in Figure 1. The towers were given name by using T and followed by continuous numbers.

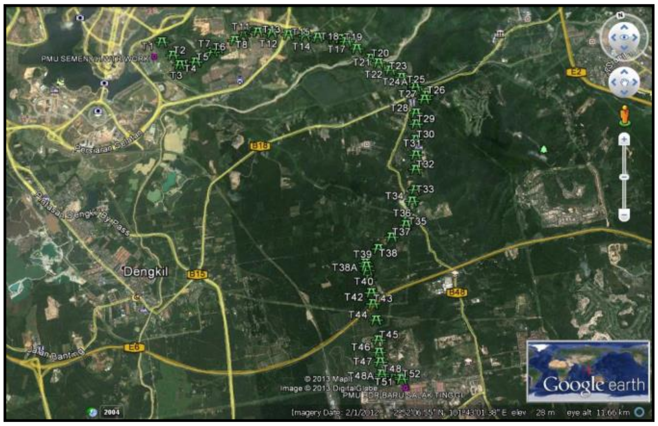

Fig. 9. Tower Location

Figure 2 shows the line end to end terrain. Tower T38A is located in the highest elevation i.e 143 m however the lowest elevation is 14 m on which tower T21 and T22 are installed.

Fig. 10. Tower Elevation

B) Tripping Records

With reference to the tripping database Centralized Tripping Information System (CTIS), a total number of 9 trippings have occurred from 2007 until 2011. This includes 2 (two) times of double circuit tripping in 2010 and 1 double circuit tripping in 2008. Table 1 shows trippings details history for 132 kV SSWW-BBST.

TABLE IX. TRIPPING HISTORY

No	Date	Time	Circuit	Remarks
1	22/4/2011	16:37	L2	Line tripped - bottom phase
2	28/5/2010	16:47	L1	Line tripped - bottom phase
3	28/5/2010	16:47	L2	Line tripped - bottom phase
4	10/5/2010	17:45	L1	Line tripped - bottom phase
5	10/5/2010	17:45	L2	Line tripped - bottom phase
6	22/2/2010	19:31	L1	Line tripped - bottom phase
7	11/12/2008	17:09	L1	Line tripped - bottom phase
8	11/12/2008	17:09	L2	Line tripped - bottom phase
9	7/10/2007	17:23	L1	Line tripped due to lightning on Distance Protection

Methodology

In other to determine whether a transmission line system require an improvement in term of performance, a lightning performance/tripping rate has to be calculated. Lightning performance is a measure of lightning-related flashover for a transmission line. Back Flashover (BF) and shielding flashover are the type of flashovers that occur in transmission lines. BF could be exhibited if a lightning strike the ground wires or towers. However, shielding flashover occurs if a lightning strikes phase conductors and an exceeded voltage that higher than the insulation strength.

For this current study the lines performance/tripping rate was calculated as follows:

$$LP = 100T/(S \times l) \quad (1)$$

At which lightning performance (*LP*) is number of tripping (*T*) divided by period of service years (*S*) and length of lines (*l*) in kilometers.

If the *LP* is lower than 1.82 tripping per 100 km per year, the lightning study is not required. However, if it is higher than 1.82 then the next step will be proceeded. From the calculation, the tripping rate for 132 kV SSWW-BBST line was 16.602 tripping per 100 km per year.

Furthermore, tower model were developed using TFlash software. All data obtained and gathered from TNB database are translated into parameters that required in TFlash software simulation. To develop the model the required data are tower types, tower impedance, tower footing resistance, installed insulator, circuit assignment, and lightning flash density. After the model accomplish, simulation could be performed.

At first the simulation was running in an originally condition before the Transmission Lightning Arrester (TLA) was installed. If irrelevant result was obtained than the entered data should be checked. Otherwise when the relevant data has been obtained, the location and quantity of TLA would be determined. The research methodology flowchart is shown in Figure 3.

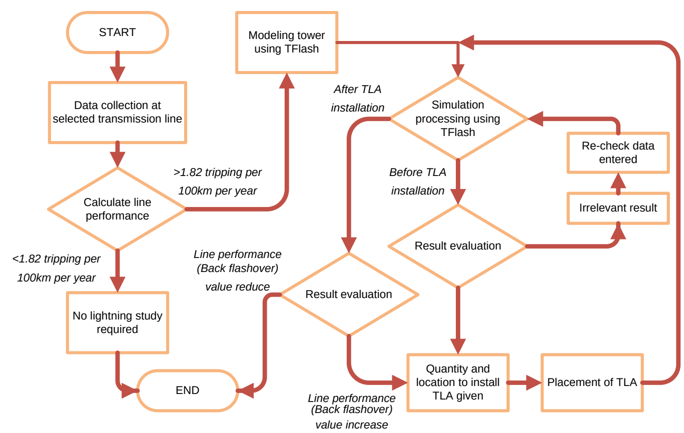

Fig. 11. Research methodology flowchart

Result and Discussion

In Figure 4, the first run simulation of line 132 kV SSWW-BBST without installed TLA is shown.

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Line Flashover Report
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Line Length:   14.624 KM
                                                    Expected Range

                  Direct Strikes Per Year:   69.935       35 to     133
                         Back Flashovers:    0.647     0.324 to   1.231
 Phase Strike/Shielding Failure Flashovers:  0.006     0.003 to   0.011
              Flashovers From Nearby Strikes: 0.000    0.000 to   0.000
                       Total Flashovers:     0.653     0.327 to   1.242

              Direct Strikes Per Year/100 KM: 478.212     239 to     909
                       Flashovers/100 KM:    4.465     2.235 to   8.492
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Fig. 12. TFlash simulation result (Without TLA)

Based on the simulation without TLA, there are 69 direct strikes of lightning to the 132 kV SSWW-BBST lines per year.

By normalizing the value per 100 km, it could be noticed that there are 478 flashovers per 100 km per year.

Concerning the BFs case, the resulted data shows that there are 0.647 strikes per year, which is equal to 1 strike in every 1.55 years. TFlash software was specially designed to handle the BF issue.

From the data, tower 7, tower 35, tower 40, tower 41 and tower 45 has undergone more than 0.02 BF per year. This rate would be reduced below 0.02 BF per year in order to improve the transmission lines performance by installing the TLA.

To find out the rate of Back Flash, the Phase Flashover Report (PFR) was referred as presented in Figure 5. As shown "Circuit 1 – Phase" C and "Circuit 2 – Phase A" have higher rates of BF than other circuits. This data would be used to determine which phase in the tower would be equipped with TLA.

Phase Flashover Report

CIRCUIT	PHASE	BACK FLASH	PHASE STRIKE FLASH	INDUCED FLASH	DIRECT STRIKES
1	A	0.174	0.003	0.000	0.041
1	B	0.327	0.000	0.000	0.036
1	C	0.348	0.000	0.000	0.020
2	A	0.348	0.000	0.000	0.019
2	B	0.327	0.000	0.000	0.036
2	C	0.174	0.003	0.000	0.041

Fig. 13. Phase flashover report

In the following step, another simulation (1st stage) was carried out with installed TLA. From the 1st stage simulation, BF/year rate for tower 35 and tower 40 are still above target rate. Therefore, PFR from 1st stage simulation must be referred to identify other phases that require TLA installation. The 1st stage PFR report is shown in Figure 6. As it can be noticed from the report "Circuit 1 – Phase B" and "Circuit 2 – Phase B" result a higher rates of BFs. Therefore, 4 (four) units of TLA is required to be installed at Tower 35 and Tower 40.

Phase Flashover Report

CIRCUIT	PHASE	BACK FLASH	PHASE STRIKE FLASH	INDUCED FLASH	DIRECT STRIKES
1	A	0.163	0.003	0.000	0.041
1	B	0.277	0.000	0.000	0.036
1	C	0.176	0.000	0.000	0.020
2	A	0.176	0.000	0.000	0.019
2	B	0.277	0.000	0.000	0.036
2	C	0.163	0.003	0.000	0.041

Fig. 14. 1st Stage Phase flashover report

Subsequently, another simulation was carried out (2nd stage) in other to observe the transmission lines performance. The result of BF/year rate for 2nd stage shows Tower 39 still above targeted rate. Further, PFR as shown in Figure 7 has to be observed in order to determine another location of TLA.

Phase Flashover Report

CIRCUIT	PHASE	BACK FLASH	PHASE STRIKE FLASH	INDUCED FLASH	DIRECT STRIKES
1	A	0.160	0.003	0.000	0.041
1	B	0.273	0.000	0.000	0.036
1	C	0.164	0.000	0.000	0.020
2	A	0.164	0.000	0.000	0.019
2	B	0.273	0.000	0.000	0.036
2	C	0.160	0.003	0.000	0.041

Fig. 15. 2nd Stage Phase flashover report

From the PFR of 2nd stage the other units of TLAs are required to be installed in "Circuit 1 – Phase B" and "Circuit 2 – Phase B" of Tower 39.

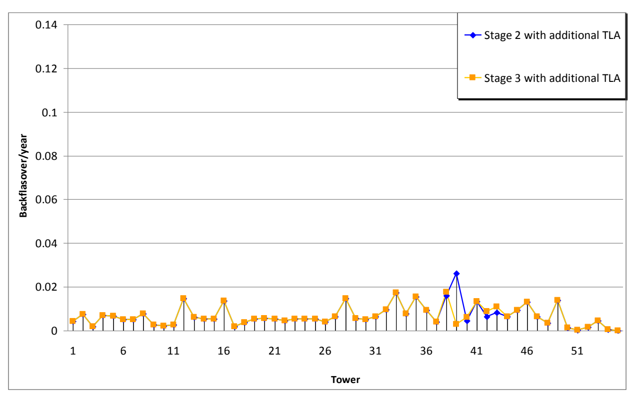

Fig. 16. Comparison for 2nd and 3rd stage of TLA installation

Finally, the 3rd stage of BF/year rate – as shown in Figure 8 – provide a acceptable result after the installation of 2 (two) units of TLA in Tower 39. The overall target has been achieved i.e. below 0.02 BF/year.

To summarize the entire process, a comparison graph between BF/year before and after installation of TLA is given in Figure 12. In total there are 16 units of TLAs are required to be installed. Furthermore, Table 2 shows the number of TLA required to be installed for 132kV SSWW-BBST OHTL.

TABLE X. REQUIRED NUMBER OF INSTALLED TLA

Circuit 1			**Circuit 2**		
A	**B**	**C**	**C**	**B**	**A**
1	**2**	**3**	**4**	**5**	**6**
0	**3**	**5**	**0**	**3**	**5**

The numbers of TLA installed is 16 units for this simulation. Figure 9 and 10 shows the final result from this simulation before and after 3rd stage of TLA installation.

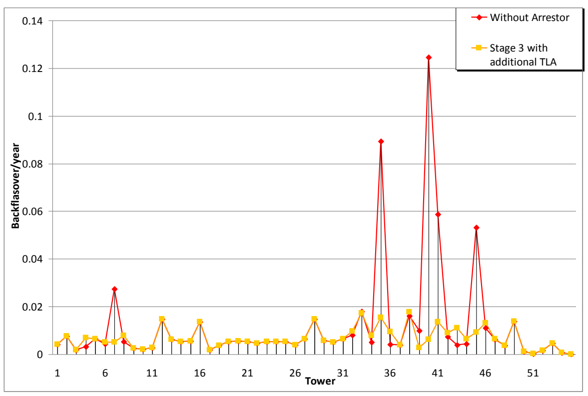

Fig. 17. Comparison graph on BF/year rate before and after 3rd stage TLA installation

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Line Flashover Report
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Line Length:    14.624 KM
                                                          Expected Range

                    Direct Strikes Per Year:   69.935        35  to       133
                           Back Flashovers:    0.367     0.184  to     0.698
  Phase Strike/Shielding Failure Flashovers:    0.006     0.003  to     0.011
              Flashovers From Nearby Strikes:   0.000     0.000  to     0.000
                          Total Flashovers:    0.372     0.186  to     0.708

               Direct Strikes Per Year/100 KM:  478.212       239  to       909
                        Flashovers/100 KM:    2.547     1.275  to     4.844
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Fig. 18. Line flashover report after TLA installation

Referring to the Figure 10, the BF rate has reduced to 0.367 per year which is equal to 1 BF in 2.72 years. At the same time, the Total Flashovers rate has also reduced to 0.372.

Conclusion

An analysis of OHTL performance of 132 kV Sungai Semenyih Water Works towards Bandar Baru Salak Tinggi (SSWT-BBST) has been accomplished by using TFlash software. From the simulation the location and quantity of TLA require to improve the transmission lines have been obtained. Based on the result, the BF was successfully reduced by approximately 56.7%.

Acknowledgment

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