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Study of induced voltage 115 kV in Lao P.D.R parallel transmission lines caused by electric field induction

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Abstract

The induced voltage generated in the transmission lines has been a significant factor for the power system because it can impact the stability and cause the work hazard to the system. This paper purposes the investigation of induced voltage occurring in 115 kV parallel transmission lines caused by electric filed induction. The dependence of induced voltage on the distance between the parallel transmission lines and conductor diameter are examined. This study performs the alternative transient program - electromagnetic transient program (ATP-EMTP) modeling to analyze the induced voltage. It was found that the induced voltage is decreased when the distance between the transmission lines are increased. For the impact of conductor diameter on the induced voltage, it was seen that the induced voltage can be reduced by decreasing the conductor diameter. Hence, the induced voltage generated in the transmission line and conductor diameter becomes the important factors, which is needed to be optimized in order to achieve the high stability power system.

Keywords: Induced voltage, Transmission lines

1. Introduction

Nowadays Lao People's Democratic Republic (Lao P.D.R) is one of the countries that are the developing power system in order to become an Asia's battery. Hence, transmitting the electrical energy with high efficiency is important because it is related to the safety and stability of the power system [1]. On the other hand, the power system collapse, such as the break of insulators, and collapses between cable and tower can be usually occurred due to the system instability [2]. Another problem in Lao P.D.R is that the induced voltage occurred in de-energized transmission lines is pretty high, especially at close proximity to the transmission lines [3-5]. Then, working against this problem becomes difficult dangerous as seen in the previous studies [3]. This problem is also related to the stability of the system. Also, the workers have to be careful while working on a de-energized transmission lines. From previous studies the characteristic of induced voltage occurred in the 49 kV and 161 kV three phase transmission line system used in USA were investigated [3]. Also the structure proposed by R. Horton et al [3] is also performed in the practical system of Lao with 115 kV, however the induced voltage occurring in this particular system has not been studied yet.

This paper aims to decrease induced voltage 115 kV in Lao P.D.R parallel transmission line caused by electric field induction in Lao power system by considering the distance between parallel transmission lines and conductor diameter. The method to decrease induced voltage by considering the distance of two parallel lines and conductor diameter is also proposed because it is very important to maintain the stability of the power system.

2. Materials and methods

2.1 Topological selection

From several previous studies [3-5], it is seemed that induced voltage depends on distance between the parallel transmission line, load, tower structure, operate voltage, frequency and conductor diameter. For this paper, the transmission lines of 115 kV in Lao P.D.R is focused. On the other hand, this paper is different from the previous, such as the structure, frequency and conductor diameter. The 115 kV parallel transmission lines of HinHuep (HH)-VangVieng(VV) and Thalat(THL)-VangVieng(VV) are illustrated in Figure 1. The transmission line parameters are detailed as follows: Phase conductor 477 26/7 ACSR (0.858″ dai.) per phase, Shield wire 7/8″ Alumoweld, Voltages 115 kV, Distance paralleled for about 65′ (Feet) and System frequency 50 Hz.

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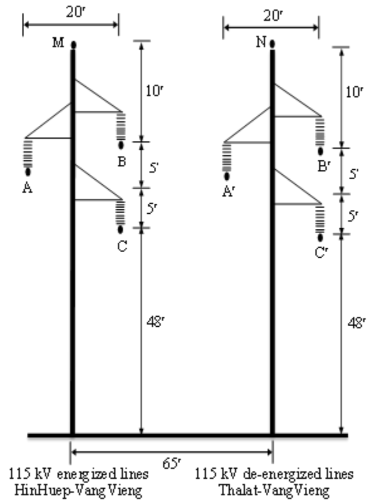

Figure 1 Two parallel three phase transmission lines

2.2 Concerned methodology

The method to calculate the induced voltage is (ATP-EMTP) modeling. (ATP-EMTP) modeling is one of the method which is normally performed for solving the matrix system. It has several advantages compared with the other method such as: it works especially well with large systems and it is reduced to identity matrix. Also, this method is more suitable for the proposed problem than the other because it is appropriate for the site of this system and it can solve up simultaneous equations [6].

Those to calculate self-potential and mutual potential coefficient of the transmission lines were presented [3, 7]. The voltage induced is modified by using matrix with zero current of the de-energized transmission lines. The effect of shield wires is also included in the calculation of induced voltage generated from transmission lines as shown in Eq. (1).

$$[I] = j\omega[C][V] \quad (1)$$

Where $[I]$ is current phase vector (A, B, C and A′, B′, C′), $[C]$ is matrix capacitance and $[V]$ is voltage to ground phase vector (A, B, C and A′, B′, C′).

From Eq. (1), the steady state current of the proposed system can be written in Eq. (2). Then, the induced voltage $V_{a'}$, $V_{b'}$, $V_{c'}$ can be calculated by using Gauss Jordan which is one of the normal algorithm for solving the matrix system.

$$\begin{bmatrix} I_a \\ I_b \\ I_c \\ I_M \\ 0 \\ 0 \\ 0 \\ I_N \end{bmatrix} = j\omega \begin{bmatrix} C_{aa} & C_{ab} & C_{ac} & C_{aM} & C_{aa'} & C_{ab'} & C_{ac'} & C_{aN} \\ C_{ba} & C_{bb} & C_{bc} & C_{bM} & C_{ba'} & C_{bb'} & C_{bc'} & C_{bN} \\ C_{ca} & C_{cb} & C_{cc} & C_{cM} & C_{ca'} & C_{cb'} & C_{cc'} & C_{cN} \\ C_{Ma} & C_{Mb} & C_{Mc} & C_{MM} & C_{Ma'} & C_{Mb'} & C_{Mc'} & C_{MN} \\ C_{a'a} & C_{a'b} & C_{a'c} & C_{a'M} & C_{a'a'} & C_{a'b'} & C_{a'c'} & C_{a'N} \\ C_{b'a} & C_{b'b} & C_{b'c} & C_{b'M} & C_{b'a'} & C_{b'b'} & C_{b'c'} & C_{b'N} \\ C_{c'a} & C_{c'b} & C_{c'c} & C_{c'M} & C_{c'a'} & C_{c'b'} & C_{c'c'} & C_{cN} \\ C_{Na} & C_{Nb} & C_{Nc} & C_{NM} & C_{Na'} & C_{Nb'} & C_{Nc'} & C_{NN} \end{bmatrix} \begin{bmatrix} V_a \\ V_b \\ V_c \\ 0 \\ V_{a'} \\ V_{b'} \\ V_{c'} \\ 0 \end{bmatrix} \quad (2)$$

Where V_a, V_b and V_c are the phase voltages of energized transmission lines which are $66{,}395 \angle 0° \text{ V}$, $66{,}395 \angle -120° \text{ V}$ and $66{,}395 \angle 120° \text{ V}$, respectively and $V_{a'}$,$V_{b'}$ and $V_{c'}$ are the phase voltages of de-energized transmission lines.

In order to investigate the induced voltage occurred in the parallel transmission line, the distance between conductors (D) was varied from 40 to 90 ft. and conductor diameter (r) was varied 0.642″to 0.927″.

3. Result and discussion

The double circuit 115 kV transmission lines structure is shown in Figure 1. It is given as an example of the calculation from the safety distance of the worker and stability of the power system. The proposed tower structure of 115 kV transmission lines has the parallel distance between each other about 65′. From Eq. (2), the phase voltage of the de-energized transmission lines was computed by the distance between two transmission lines. The results of de-energized transmission line induced voltage calculated at 65′ and the conductor diameter = 0.858″ which is the practical value used in Lao P.D.R power system are Phase A′ = 2,087 V, Phase B′ = 1,113 V and Phase C′ = 1,119 V.

Figure 2. shows the induced voltage occurred in phase A′, B′ and C′ of de-energized transmission line with varying the distance between the transmission lines from 40 to 90 ft. It is shown that the induced voltage of phase A′, B′ and C′ are reduced with an increase of distances. When the distance between transmission lines is widen, Capacitance (C) of phase conductor is reduced. As a result, the induced voltage will be reduced [3]. It is also seem that the phase induced voltages are becoming ≤ 1000 V at the transmission line distance further than 90 ft. The distance at 90 ft. is the suitable distance for Lao P.D.R power system. Also, it is observed that $V_{a'}$ is higher than $V_{b'}$ and $V_{c'}$ at the transmission line distances. This is because phase A′ transmission line has closet distance to the energized transmission lines which further cause the highest capacitance of phase conductor.

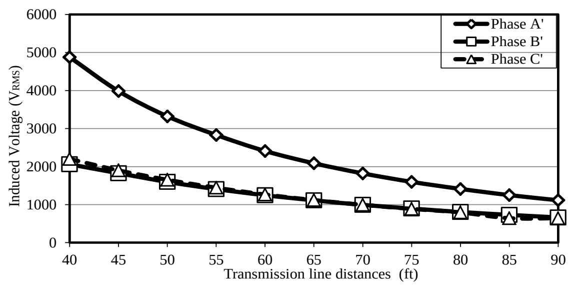

Figure 2 Relationship between the induced voltages and transmission line distances

Figure 3. shows the induced voltage occurred in phase A′, B′ and C′ of de-energized transmission line with varying the conductor diameter (r) from 0.642′′ to 0.927′′. It is shown that induced voltage of phase A′, B′ and C′ de-energized transmission line are increased with an increasing of conductor diameter. When the conductor diameters are increased, the capacitance (C) of phase conductor is increased. Accordingly, the induced voltage will be increased. It is also noticed that the induced voltage of phase A′ is higher than those of phase B′ and C′ due to the same cause as described previously.

From Figures 2 and 3, it is indicated the induced voltage occurring in the transmission line can be impacted either by varying the distance between the transmission lines or conductor diameter. From the result, it is found that the distance between the transmission lines has more influence on the induced voltage than conductor diameter because the capacitance of phase conductor can be significantly impacted by varying the distance between the transmission lines. In the practical power system, reducing the induced voltage by increasing the distance between the transmission lines is more practical than conductor diameter. This is because there

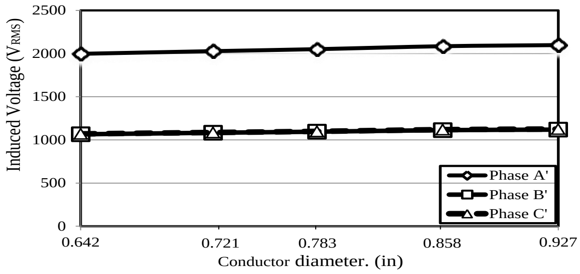

Figure 3 Relationship between the induced voltages and conductor diameter

is the limitation on transmitting the decreasing power regarding the particular system. Especially the induced voltage can be efficient reduced by increasing the distance between the transmission lines rather than decreasing conductor diameter, as found in the simulation results. However, increasing the distance between the transmission lines could impact the power system in terms of constructive area. Thus, the distance between the transmission lines and conductor diameter become the important factor regarding the induced voltage occurring in de-energized transmission line and need to be optimized in order to achieve the efficient power system.

4. Conclusions

From the simulation results, it was found that the induced voltage can be decreased either by increasing the distance between the transmission lines or decreased the conductor diameter. This induced voltage could be developed into a de-energized transmission lines by a mechanism called electric field induction. This induced voltage generally depends on the distance between the two lines and the size of the conductors. According to this study, it was indicated that the induced voltage generated in the system was lower than 5 kV. So, the working on the de-energized transmission lines will be safe. On the other hand, the appropriate performance would be used when installing protective grounds to make sure that the dangerous are adequately exist.

5. Acknowledgements

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