Power Line Induction affect to Subscriber's telephone during GDTs' failure.

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Abstract: - This paper reports the results of a case study on a given telecommunication circuit configuration paralleling to both 22 kV and 115 kV power lines by using the same utility poles. This study uses simulation Electromagnetic Transients Program (EMTP/ATP) to simulate and shows that during normal operation of the power system some level of differential mode voltage is present across the tip and ring conductor. Upon occurrence of a fault in 22 kV and 115 kV lines, maximum values of fault currents are calculated to be 557 and 3492 amperes respectively. The higher differential mode voltage during the occurrence of a fault in either 22 kV or 115 kV lines does not cause any potential damage. If the GDT is out of order and then have any fault in power lines system. Since induced voltage that cause from power line will building up across the conductors of telephone line and would become to common mode voltage. The analytical results on the common mode voltage due to either 22 kV or 115 kV line faults can caused serious hazard and make damage to subscriber's telephone equipment. This paper introduced to recommendations on the mitigation the influence of power line induction to subscriber's telephone during GDTs' failure.

Key-words: - Power line induction, Telecommunication system, Differential Mode Voltage, Common Mode Voltage, Surge Protective device and Gas Discharge Tube

1 Introduction

The most of telecommunication system in Thailand installs telecommunication lines together with power lines that comprise both high and low voltage transmission system. This telecommunication system are installed together along with 22 kV and 115 kV power lines, thus these powers systems may be interference to subscriber's telephone lines cause from effect of power line induction. This effect may significant to damage for subscriber's telephone and equipment. The damage of that has two patterns are knows as differential (V_D) and common mode voltage (V_C) can insight by consider fig.1.

The gas discharge tube (GDT) as shown in fig.2 is used as surge protector device that service provider will installed at far end of subscriber's telephone to protected overvoltage as shown in fig.3.

The GDT have three polar, characteristic according to [1] [2] and [3]. In sometime, GDT may be damaged due to several causes that can be divided in three principal factors which include

1. The magnitude of overvoltage that larger than the protective rating of GDT
2. The magnitude of overvoltage is lower than the protective rating and occurred longtime than ability to withstand these by GDT, such that generated heat and accumulate more in GDT and finally cause damage of GDT.
3. Unfortunately, have substance to connect or short path between the GDT polar such as the moisture dust or the ants at the same time occur the overvoltage so may be forming arc and made melting and permanent connecting.

All causes above might be affected to subscriber's telephone equipment and subscriber's telephone equipment is damaged.

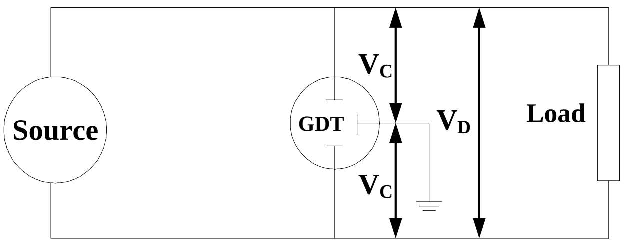

Fig.1 Differential mode voltage and common mode voltage.

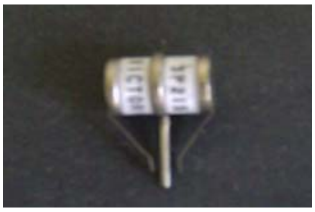

Fig.2 Gas discharge tube (GDT)

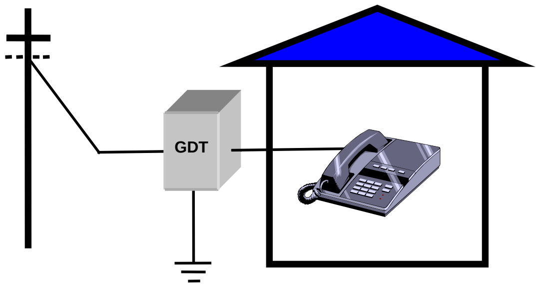

Fig.3 Installation of Gas discharge tube (GDT)

2 Overvoltage due to power line induction

Damage to a telephone system which may be attributed from electric power lines can occur by two ways: (1) magnetic induction, and (2) direct contact between overhead power lines and aerial telephone facilities (cable).

Since power and telephone lines are installed together, although separated with some distance between them but it might be fairly high resultant of coupling. In addition earth resistivity also has a bearing on severity between the powers and telephone system coupling, so we can get differential and common mode voltage as shown in fig.4 and 5 respectively.

Even if there is a high magnitude of unbalanced earth return current, voltage may be induced on the telephone system metallic elements in sufficient magnitude that may be dangerous to personnel working on the telephone system also affect to increase magnitude of differential mode voltage and common mode voltage shown in fig.6 and 7 respectively. The high current may be caused by power system load unbalance or a fault condition. The induced voltage may result in hazards to the public, acoustic shock, and damage to telephone plant.

Regarding the induced voltage (e), is expressed by the formula [4]:

$$e = -I.Z_m \qquad V/km \qquad (1)$$

where

I = The load current or fault current flows in a line that parallel to telecom conductor

Z_m = The mutual impedance between the lines

The induced voltage will damage to equipment of telecommunication sites, subscriber's telephone and may cause damage to copper cable facilities as a result of over stressed dielectric levels by pair-to-pair, pair-to-shield, and shield-to-ground. In addition, the frequency spectrum produced by such interference will most likely disrupt communication and reduced the level of security and reliability of service.

3 The simulation of fault on power system that affect to subscriber's telephone equipment

The simulation of telecommunication high and low voltage system used Electromagnetic Transients Program (EMTP/ATP) by simulate the configuration of drop wire and both 22 kV and 115 kV power lines following PEA standard in Thailand shown in fig.8. The analysis of fault event on high voltage system both 22 kV and 115 kV power lines by given fault level to be 557 and 3492 ampere respectively. The analyzed result shown that the induced voltage sufficient to damage subscriber's telephone by both differential mode and common mode voltage when it get induced from power system and simulate in the condition of GDTs' failure. Particularly, in case of GDTs' tip or ring side is melted with ground as shown in fig.9 and then it have the fault condition consequently if will impact to subscriber's telephone until subscriber's telephone is damaged.

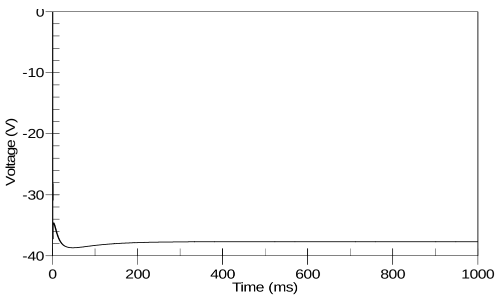

Fig.4 The normal differential mode voltage of telephone system

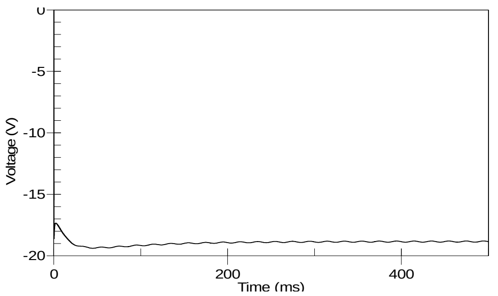

Fig.5 The normal common mode voltage of telephone system

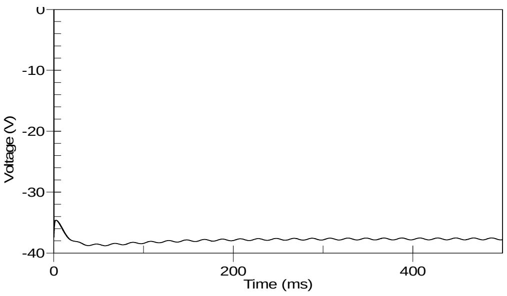

Fig.6 The differential mode voltage of telephone system when telephone system is induced from power system

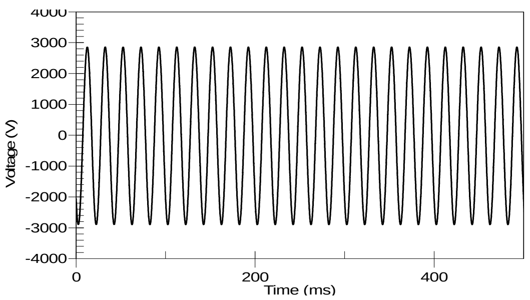

Fig.7 The common mode voltage of telephone system when telephone system is induced from power system

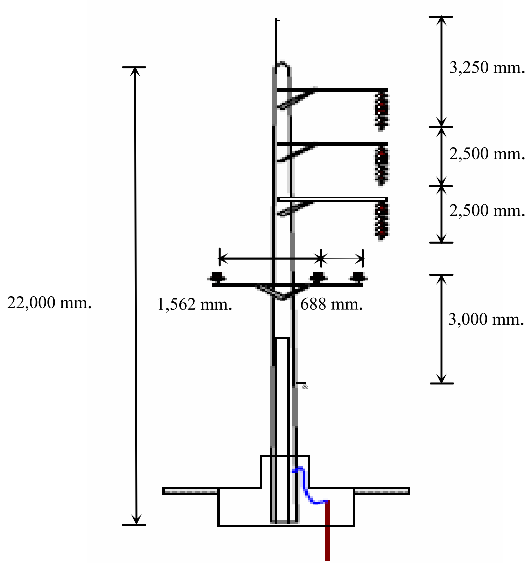

Fig.8 The arrangement of telecommunication line under power transmission line.

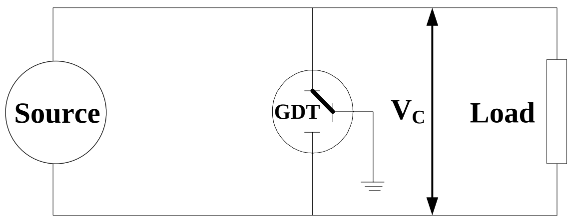

Fig.9 The pole of GDT has melting and connecting with ground.

4 Results

The overvoltage analysis on telecommunication system due to power lines induction by simulated the telecommunication system nearby the high voltage system, both 22 kV and 115 kV power lines. In ordinary telecommunication system will got the induced voltage in form of differential and common mode voltage. These voltages will not affect to subscriber's telephone because subscriber's telephone is floating grounded system, so subscriber's telephone usually operated in differential mode voltage situation. Although if power line have a fault neither in 22 kV or 115 kV lines and sometime cause from the both, the differential mode voltage still meaning less to effect subscriber's telephone. Fig 10 and 11 shows differential mode voltage result caused fault in 22 and 115 kV system respectively. Because in high voltage protection system had delay for fault disrupt so subscriber's telephone can participate the overvoltage.

In the case of GDTs' malfunction, at the tip or ring side is connected (or melted) with ground such it cause to impact the voltage drop of subscriber's telephone to become common mode voltage condition shown in fig.12. This common mode voltage will makes noise to subscriber's telephone and if after this event and then occurred of a fault in either 22 kV or 115 kV lines so subscriber's telephone receive overvoltage until it damage shown in fig. 13 and 14 respectively. This damage occurred due to the common mode voltage higher than withstand of subscriber's telephone

Even if there have noise signal on a subscriber's telephone. Service provider has to quick checked the surge protective device of subscriber's telephone and if this event appears. The subscriber's telephone immediately should change the surge protective device or report to the competent authorities in order to no damage with the telephone.

5 Conclusions

The surge voltage that come into subscriber's telephone equipment can protect by installed surge protective device but sometime the magnitude of surge voltage may have larger or lower than the surge protective rating but if this surge cause by take time longer than withstand time of surge protective device or have the queer thing inside between the pole of surge protective device. So, the surge protective device is damaged. This damage of surge protective device may affect to subscriber's telephone equipment then following by subscriber's telephone damaged.

However, Even if there is noise signal on a subscriber's telephone such as hum sound when uses it. The subscriber's telephone has to checked the surge protective device and if this event appears. The subscriber's telephone should be change the surge protective device immediately or report to the competent authorities in order to avoid damage of the telephone.

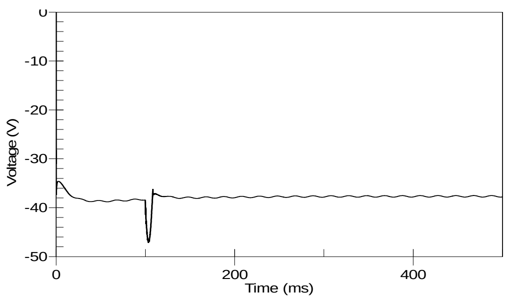

Fig.10 The differential mode voltage when power line induction during the occurrence of a fault in 22 kV lines

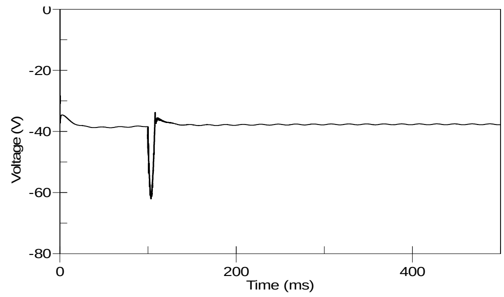

Fig.11 The differential mode voltage when power line induction during the occurrence of a fault in 115 kV lines

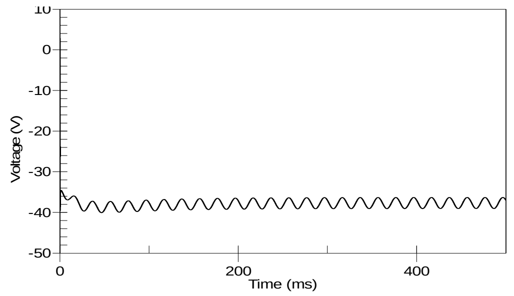

Fig.12 The differential mode voltage when telephone system is induced from 22 kV and 115 kV lines while GDT's failure

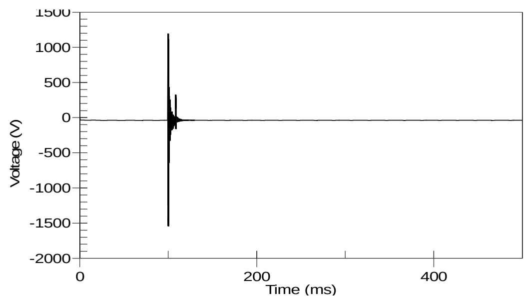

Fig.13 The common mode voltage during occurrence of a fault in 22 kV lines and while GDT's failure

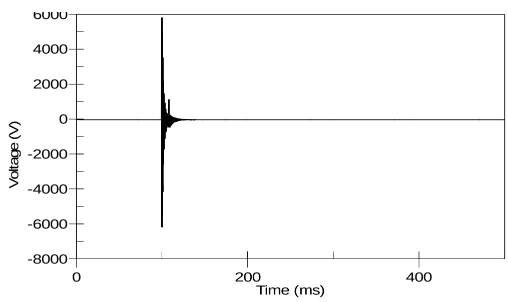

Fig.14 The common mode voltage during occurrence of a fault in 115 kV lines and while GDT's failure

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