

Effect of Surge Arrester on Overhead Transmission Lines as Shield against Over Voltage

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Abstract: This paper describes the usage of surge arrester to reduce effect of lightning stroke on transmission line. Voltage induced on overhead transmission lines due to lightning phenomena is one of the major reasons for the flash over voltage and outages. Lightning being one of the most natural and serious causes of high voltage. Determination of the maximum voltages induced on the overhead line by direct stroke is a complex problem. Distribution circuits typically are not insulated to withstand direct lightning strokes, as a result, direct strikes will cause a flash over between phase to phase or phase to ground depending upon the arc path. For estimating the flashover due to direct strokes, it is necessary to calculate the maximum voltage induced on the line. The effect of direct lightning on transmission lines have been analyzed with and without the help of surge arrester.

Keywords: Surge arrester, over voltage, conductor, lightning, flash over.

I. INTRODUCTION

On many transmission lines lightning impulse is the main cause of unscheduled supply interruption. A number of methods for estimating trip out rates have been deployed. The voltages produced on overhead lines by lightning might be due to indirect or direct strokes. Therefore a lightning stroke to a transmission line conductor injects a transient current of several thousand amperes. Our aim is to obtain maximum over voltage value that might occur on the transmission system for analysis purpose. Various circuit configurations is selected from the existing 11KV transmission system. The objective is to calculate induced over voltage from lightning. As a consequence, their evaluation has been for years, and is still, one of the most important problems in designing and coordinating the protection of overhead transmission lines. A better knowledge of the over voltages experienced on a simple 11KV circuit could improve our ability to select equipment such as switches, arresters and BILs level of transformer. It would also provide input into the design parameters for live line tools, cover up equipment, insulation levels and barriers used to build or maintain such transmission systems.

II. METHODOLOGY:

Arresters have been introduced for the protection of transmission lines as an alternative to overhead ground wires. They are placed out at intervals on the poles or towers. Voltage across the line insulator at the point of installation is controlled by the MOV (Metal Oxide Varistors) and kept below flashover voltage of the insulator to avoid back flashover which is most frequent form of lightning outage. The voltage across the line insulation is greatly influenced by the high tower footing resistance.

The entire lightning event is referred to as a flash and the individual pulses are referred to as strokes and when this current injects on phase conductor, voltage waves radiate from the point of contact in both directions along the conductor and down the tower if flashover occurred across insulator to tower. These waves rapidly encounter discontinuities which initiate reflected waves, which generate another waves when they return to the stricken point. In this way a large number of waves are generated in short order. The effect of these waves will depend on the change of surge impedance at this discontinuity.

The potential difference across the suspension insulators is of particular concern since a flashover can occur and a fault be placed on the phase if this voltage becomes excessive.

When direct lightning strikes on overhead phase conductors, magnitude of the current and high frequency nature of the stroke causes voltage surges to be propagated in both directions from the point of strike and the two travelling voltage waves originates having magnitude:

$$e = \frac{1}{2} * Z * I$$

Where,

e= voltage induced

Z= Surge impedance

I = current

III. ASSUMPTION OF DATA

In lightning surge studies many simplified assumptions are made since the waveshape and amplitude of the current source represents the lightning stroke which is obviously not well known.

Lightning wave assumed (as per IEEE Standard, 1947) 1.2/50 μ sec with 30 K Amp of current magnitude.

Inductance of surge arrester lead was assumed 0.001 mH.

Wave speed are approximately equal to speed of the light with surge impedance in phase quantities.

Only six spans near to surge arrester assumed with different span lengths, reflections from the other section whose surge impedance assumed to be 37.6 Ω and 300.0 Ω .

Six spans of 11 KV & tower no ranging from Po to P6 is taken.

Travel time is the min time taken by the wave to travel between two node and 10% of shortest travel time for o/p time scale is supposed so that better o/p is obtained from analytical point of view.

It is very important to know that electrically which section is treated as one span for lightning stroke but mechanical supports are supposed at different intervals.

Surge impedance on 11 KV line are calculated for conductor type Panther.

Input data required to calculate the surge impedance on MATLAB.

Data Input for Panther type of conductor:

S.No	Conductor Type	Diameter of conductor	Resistance at ambient temp	Height of conductor at pole	Height of conductor from ground in mid span	Tower footing resistance
1.	Panther	21.0	0.1363	9.448 m	9.144m	0.5 Ω

IV. CASE STUDY

Following two cases were selected, in which location for lightning is same, the only difference is that in one case surge arrester is enabled whereas in another case surge arrester is disabled. By analyzing both the cases, the importance of surge arrester can be determined.

Case No.1. Lightning stroke striking on conductor [Panther] away from substation and surge arrester is not enabled.

Case No.2. Lightning stroke striking on conductor [Panther] away from substation and surge arrester is enabled.

Surge protection has been a primary concern when connecting devices and equipment to low, medium, or high-voltage electrical systems. As the use of products and equipment with components and insulation systems vulnerable to voltage surges and spikes continues to increase, the requirement for surge arresters to protect against the effects due to lightning strikes, switching phenomenon, etc., continues to increase as well. From personal computers to HV transmission and distribution systems, everything is susceptible to these surges and their destructive effects. This Arrester facts is about the switching surge from an arrester perspective. This text does not try to add any new data to the vast knowledge database on switching, but is an overview of the effect switching surges have on the power systems and how arresters mitigate that effect. Surge arrester being defined as: "A protective device for limiting surge voltages by discharging or bypassing surge current, and it also prevents the flow of follow current while remaining capable of repeating these functions". The switching surge comes in many different forms, and has many different sources.

Classifications Of surge arresters:

Originally, there were three types of surge arresters. They are:

1. Expulsion type
2. Nonlinear resistor type with gaps (currently silicone-carbide gap type)
3. Gapless metal-oxide type.

There are four classifications of surge arresters. They are:

1. Station class
2. Intermediate class
3. Distribution class (heavy, normal, and light duty)
4. Secondary class (for voltages 999V or less)

Of the three types noted above, the expulsion types are no longer being used. The nonlinear resistor type with gaps was utilized through the middle of the 1970s and is currently being phased out. The conventional gap type with silicone-carbide blocks/discs are still being used and the gapless metal-oxide type are the most widely used today. Secondary class is not addressed in this article.

Station class:

With respect to the four classes of surge arresters, the station class surge arrester is the best because of its cost and overall protective quality and durability. It has the lowest (best) available protection level and energy discharging capability with successively higher (poorer) protection levels for the other classifications. Station class arresters are designed for protection of equipment that may be exposed to

significant energy due to line switching surges and at locations where significant fault current is available. They have superior electrical performance because their energy absorption capabilities are greater, the discharge voltages (protective levels) are lower and the pressure relief is greater. The value of the protected equipment and the importance of uninterrupted service generally warrant the use of station class arresters throughout their voltage range. Industry standards dictate the use of both station class and intermediate class arresters for equipment protection in the 5-to 20-mVA size ranges. Above 20mVA, station class arresters are predominately used.

Intermediate class:

Intermediate class arresters are designed to provide economic and reliable protection of medium voltage class power equipment. Intermediate arresters are an excellent choice for the protection of dry-type transformers, for use in switching and sectionalizing equipment and for the protection of URD cables. Traditional applications include equipment protection in the range of 1 to 20 mVA for substations and rotating machines.

Distribution class (heavy, normal, and light duty):

Distribution class arresters are frequently used for smaller liquid-filled and dry-type transformers 1000 kVA and less. These arresters can also be used, if available in the proper voltage rating, for application at the terminals of rotating machines below 1000 kVA. The distribution arrester is often used out on exposed lines that are directly connected to rotating machines. As noted above, the distribution class has several duty ratings, which are dependent upon the test severity. Heavy-duty arresters are more durable and have lower protective characteristics. The housing/enclosure construction of surge arresters can be of either polymer or porcelain.

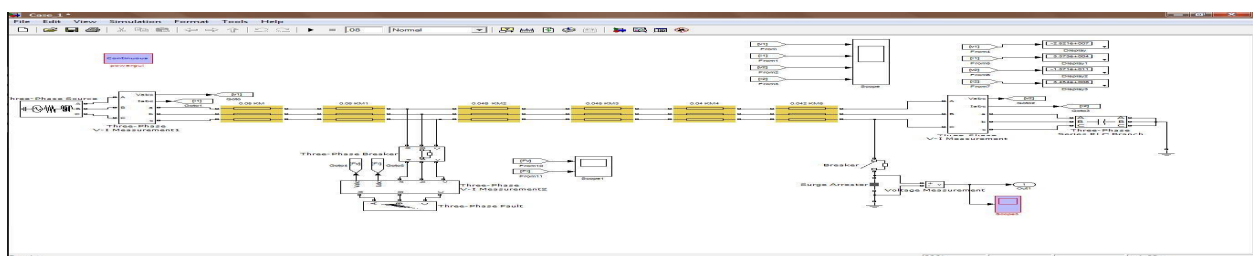
All of the system parameters need to be considered while choosing an arrester classification. If the actual arrester energy duties are not known and a transient study cannot be performed, then it is suggested that Station class arresters be applied. This is a conservative approach that reduces the chances of misapplication

Gapless metal-oxide surge arrester (MOSA), provides the best performance and reliability. Both the gap and gapless type arresters do the same job and the selection and application process of both types are similar. However, the need to select higher voltage levels for the silicone-carbide gap type and the possibility of contamination of the gap means the protection and reliability is slightly less. When gapped type arresters fail, they are replaced by the metal-oxide gapless type.

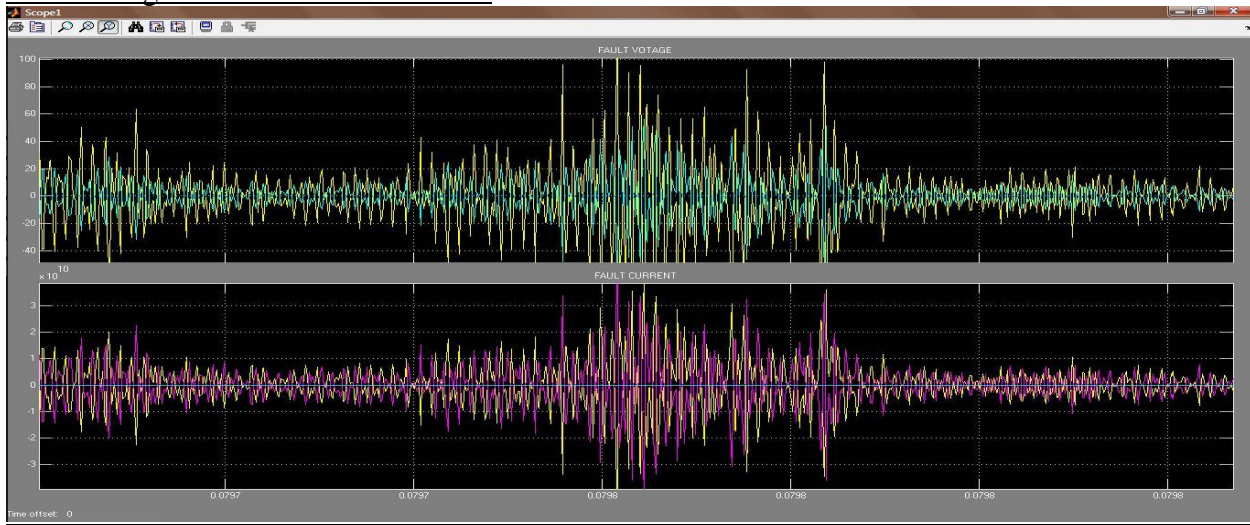
V. RESULTS

Case No.1. Lightning stroke striking on conductor [Panther] away from substation without surge arrester.

Circuit Diagram



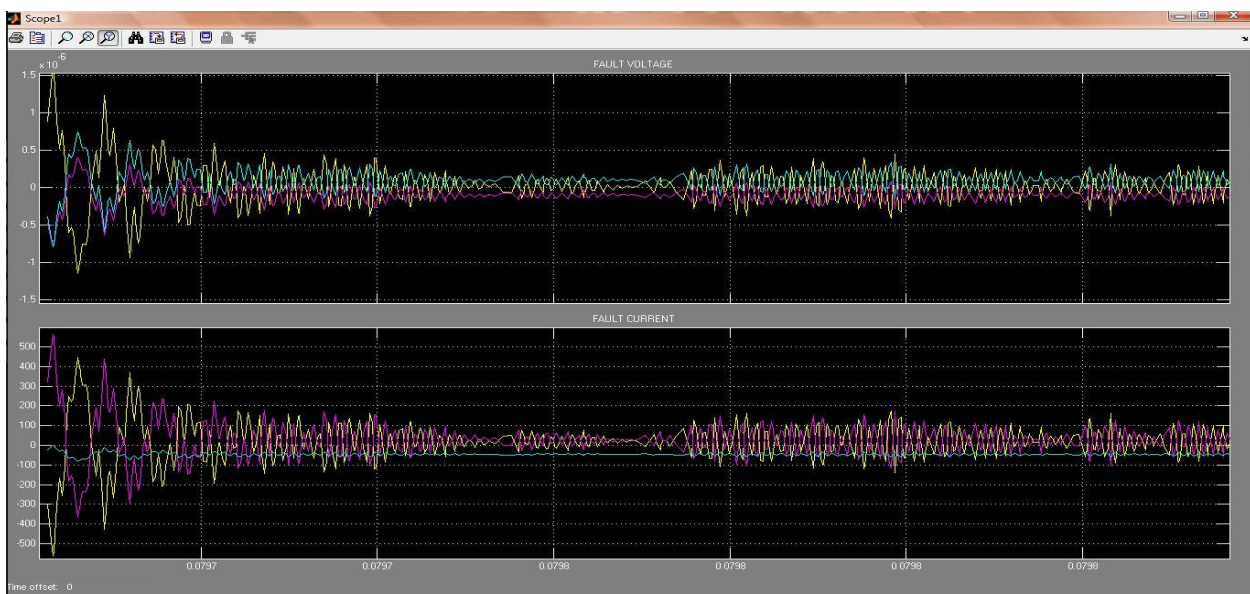
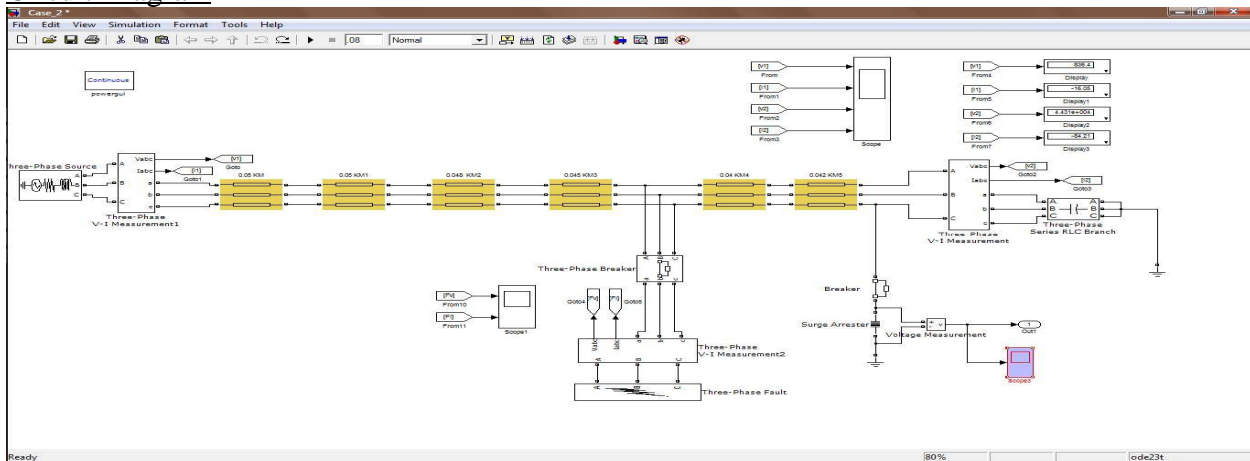
Fault voltage & fault current of case 1



Case No.2.

Lightning stroke striking on conductor [Panther] away from substation and surge arrester is enabled.

Circuit Diagram



VI. CONCLUSION

Unlike the lightning surge, the switching surge is generally self-induced by the operation of a breaker, switch or disconnect switch. However switching surges can be associated with lightning if during a lightning storm a lightning surge causes a breaker to operate and a switching surge is induced. The wave shape is very complex. The amplitude of this switching surge is about 2.5pu which is a quite common amplitude for switching surges. Also note the duration of this event is not much more than one power frequency cycle which again is quite common in switching surge events. Hence, after analyzing Case 1 & Case 2, finally conclusion is reached that in order to reduce the effect of lightning surge **arrester must be enabled** as induced voltage gets effectively reduced due to it.

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BIOGRAPHY

Swati Agrawal received BE degree in Electrical Engineering from Pt Ravi Shankar Shukla University in the year 2006. She has completed her M.E (by Research) from Yashwant Rao Chavan College of Engineering, Nagpur University. Since 2007, she is working with MATS University, Raipur (C.G).Her area of interested is high voltage, power electronics. Email id:swatiagrawal21@yahoo.co.in