Surge Arrester Placement for Substation Lightning Protection

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Agenda

- Introduction
- Modelling
- Results
- Conclusions

Introduction

Introduction

- Most utilities install surge arresters at both the entrance of the substation and the terminal of the transformer.

- Due to the high installation cost of surge arresters, some utilities like Salt River Project (SRP) only install the surge arrester at the transformer side.

Introduction

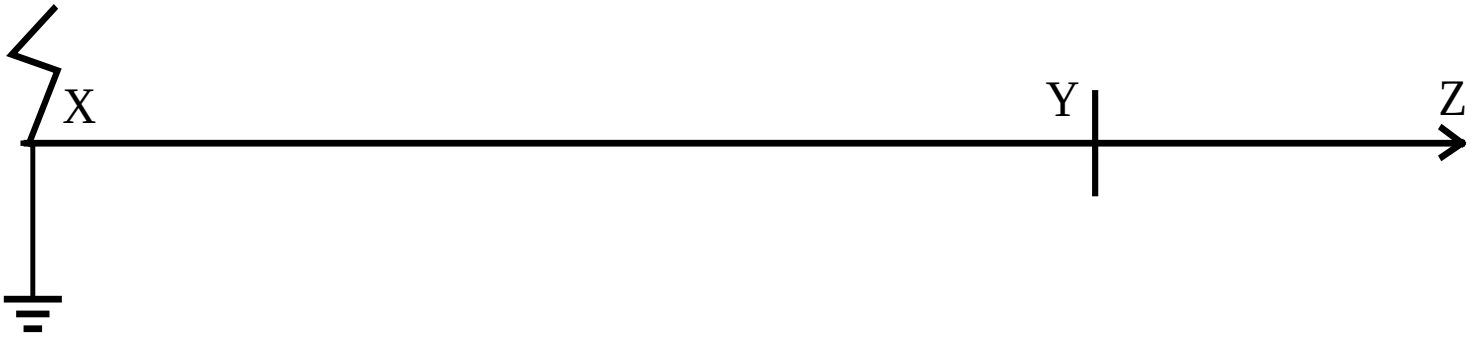
Two major concerns:

- Critical point
  - maximum recommended length of the transmission line before an arrester needs to be applied
- Performance for different surge arrester configurations

Introduction

Definition of critical point

Lightning strokes are applied at different distances from the entrance point. The corresponding lightning stroke location of the maximum voltage at the entrance of the substation or the terminal of the transformer is defined as the critical point.



Introduction

Four different surge arrester configurations for substation lightning protection are considered:

- C1: No installed surge arrester on the substation
- C2: Surge arresters are installed at the entrance of the substation and at the terminal of the transformer respectively.
- C3: Surge arresters are only mounted at the entrance of the substation;
- C4: Surge arresters are installed on the terminal of the transformer.

Modelling

Modelling

Fast front transient model for :

- a **practical SRP** 500-230 kV substation (with **real field data**)
- a few spans of the 230kV transmission line

This Model is developed using PSCAD 4.6.0.

SRP denotes Salt River Project which is a utility located in Arizona.

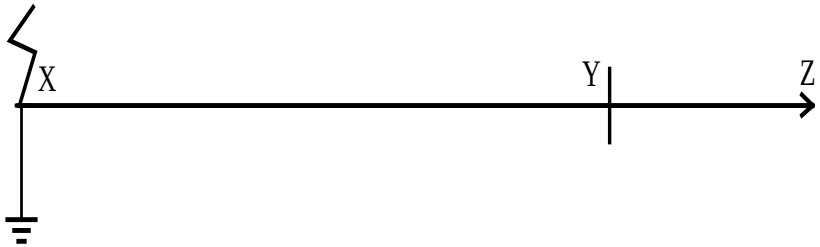
Modelling

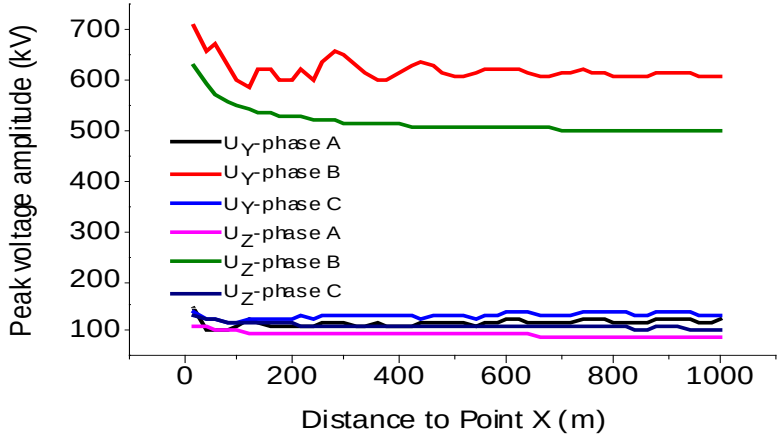
Simulation procedures :

Step 1. Model 230kV transmission line and the connected substation in PSCAD using the field data.

Step 2. Changing the distance from the lightning stroke location to the entrance of the substation.

Step 3. repeating step (2) for different protection configurations.



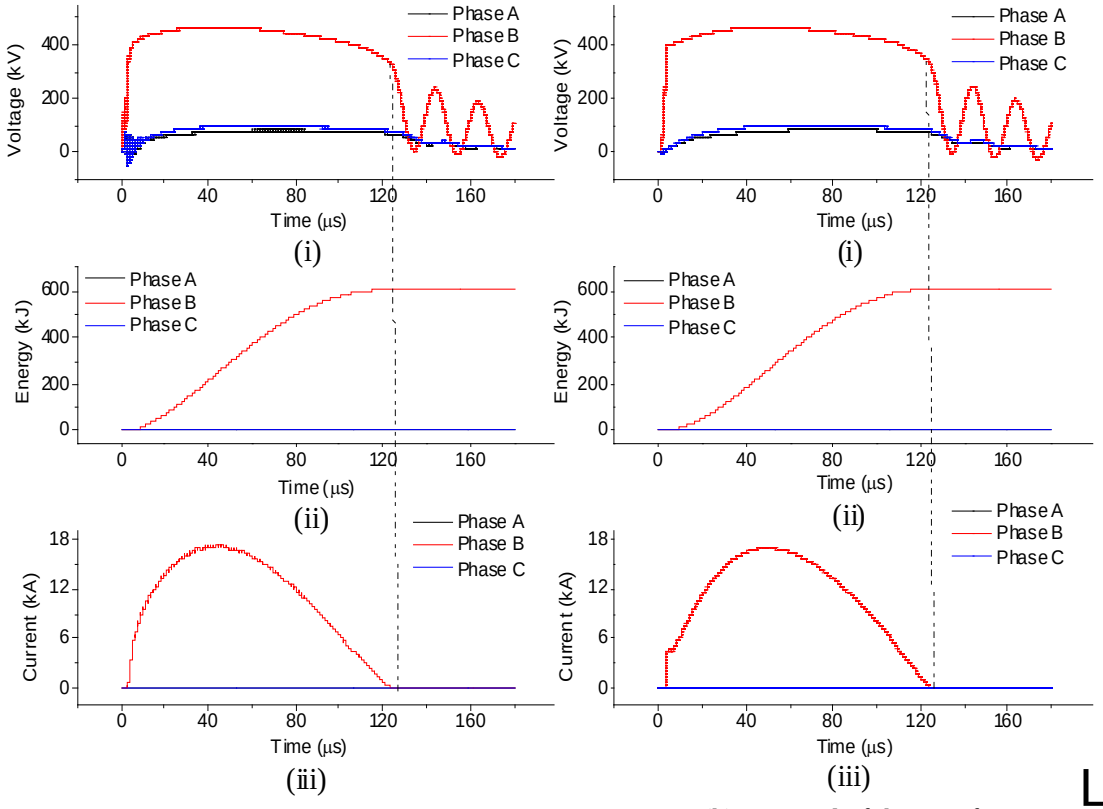


(d) C4- One surge arrester on Point Z

Results

C2 : surge arresters are installed at both the entrance of the substation and the terminal of the transformer.

Direct stroke — Phase B is hit by the lightning stroke



(a) Entrance of the substation

(b) Terminal of the transformer

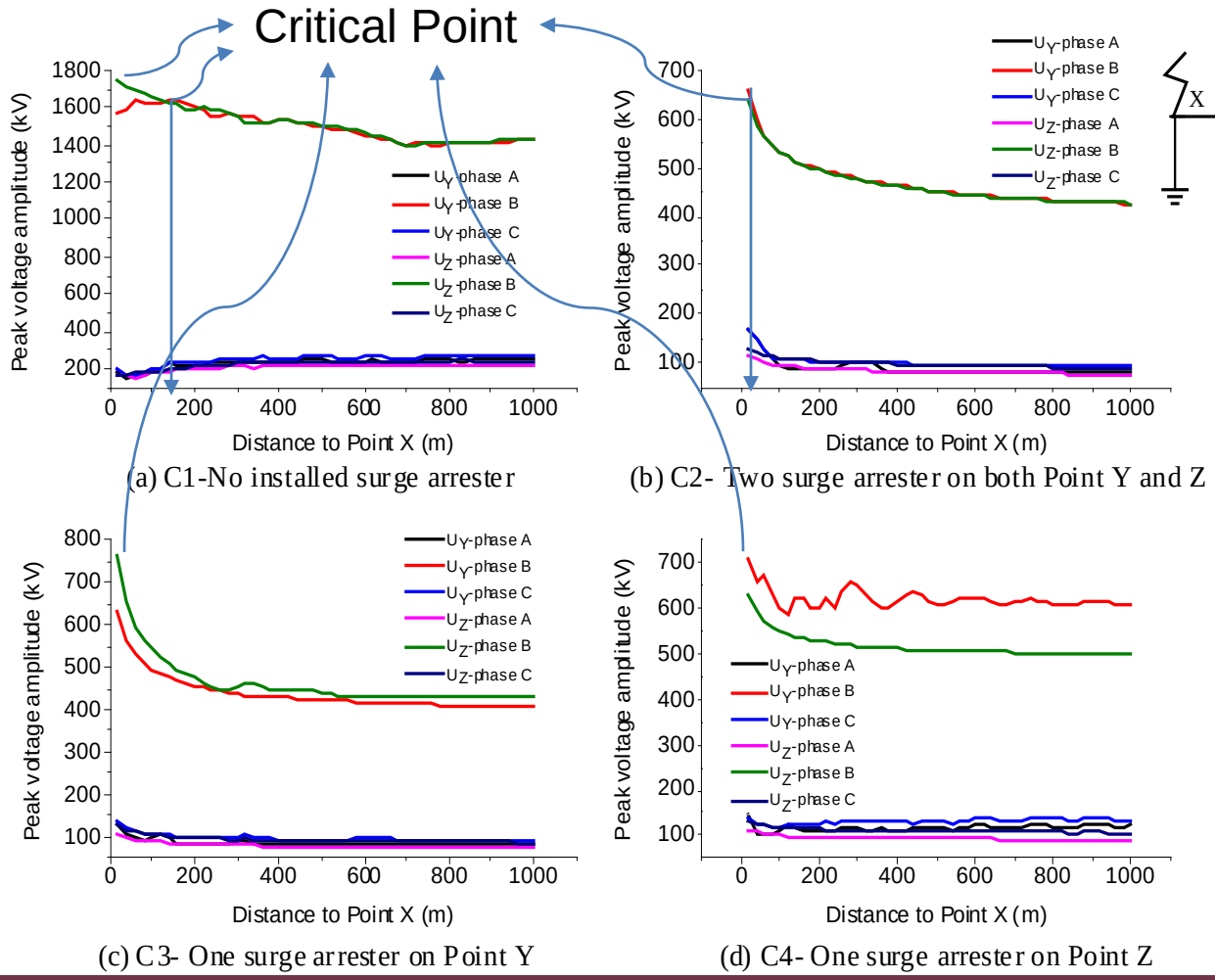
→ Arrester Voltage

→ Arrester Energy duties

→ Arrester Current

Lightning stroke distance = 20m

Voltage-distance curves

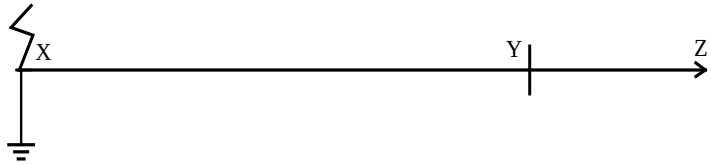


(a) C1-No installed surge arrester

(b) C2- Two surge arrester on both Point Y and Z

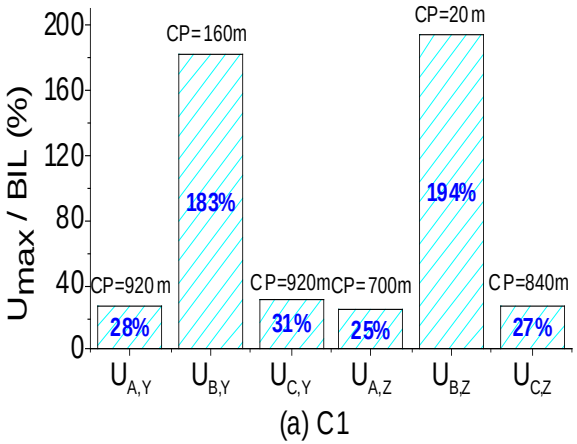
(c) C3- One surge arrester on Point Y

(d) C4- One surge arrester on Point Z

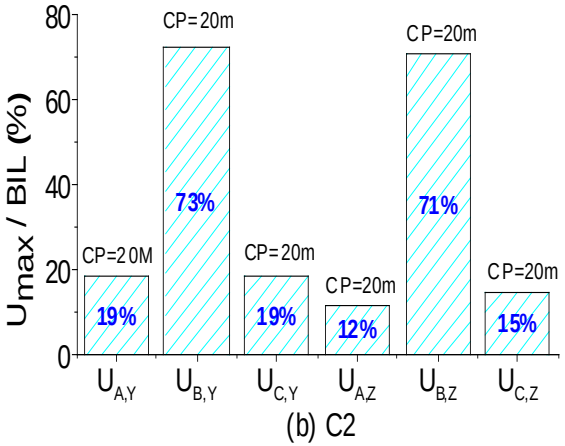


- The voltages on phase A and phase C are far less than the voltage on phase B.
- Most critical points are the closest point to the line entrance of the substation

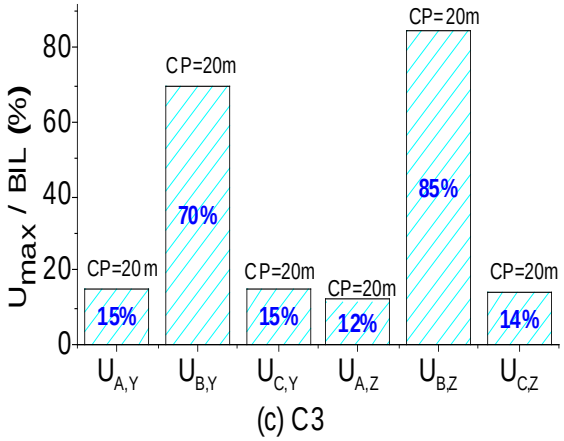
Results



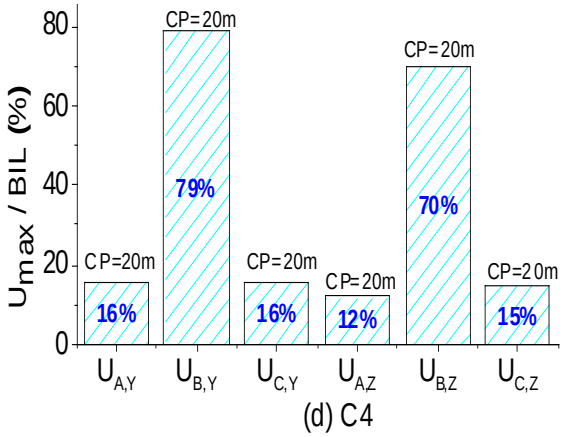
(a) C1



(b) C2



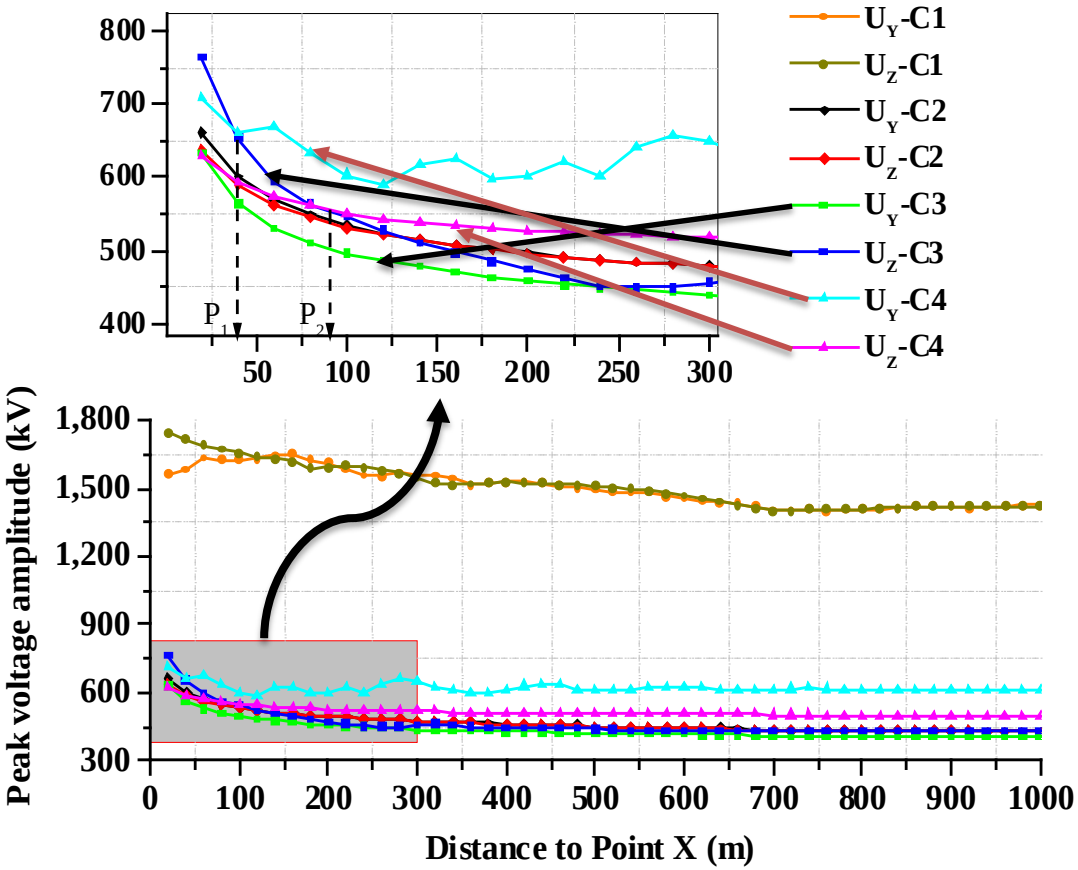
(c) C3



(d) C4

- Phase A and phase C voltages can only reach up to 31% of the BIL value
- Without surge arrester, the voltage at the transformer can reach up to 194% of the BIL value.
- C3 has the highest voltage at the transformer terminal among C2, C3, C4

Voltage-distance curve for Phase B



- C3: $U_Y < U_Z$ C4: $U_Y > U_Z$

U_Y - voltage at the entrance of the substation
U_Z - voltage at the terminal of the transformer

C3: Surge arresters are only mounted at the entrance of the substation;
C4: Surge arresters are installed on the terminal of the transformer.

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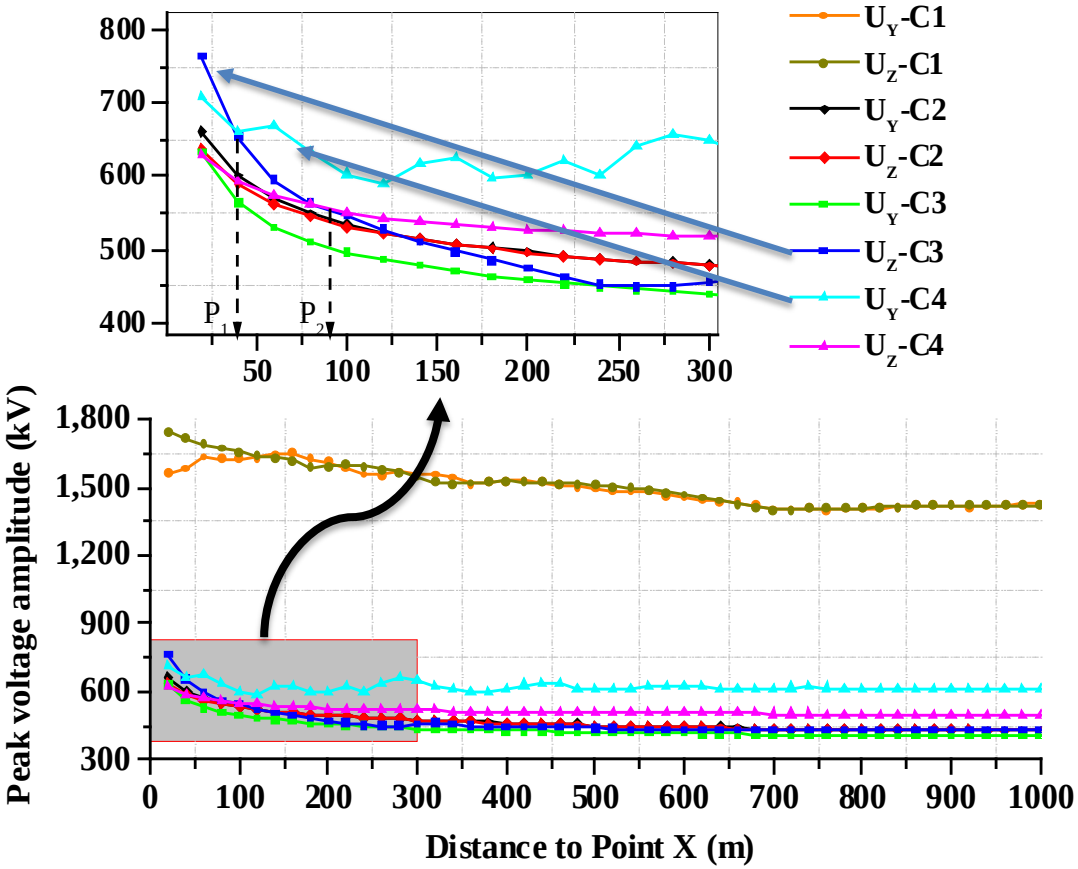

- C3: $U_Y < U_Z$ C4: $U_Y > U_Z$
- P_1 is the point of intersection of $U_Z - C3$ *and* $U_Y - C4$

U_Y denotes the voltage at the entrance of the substation

U_Z denotes the voltage at the terminal of the transformer

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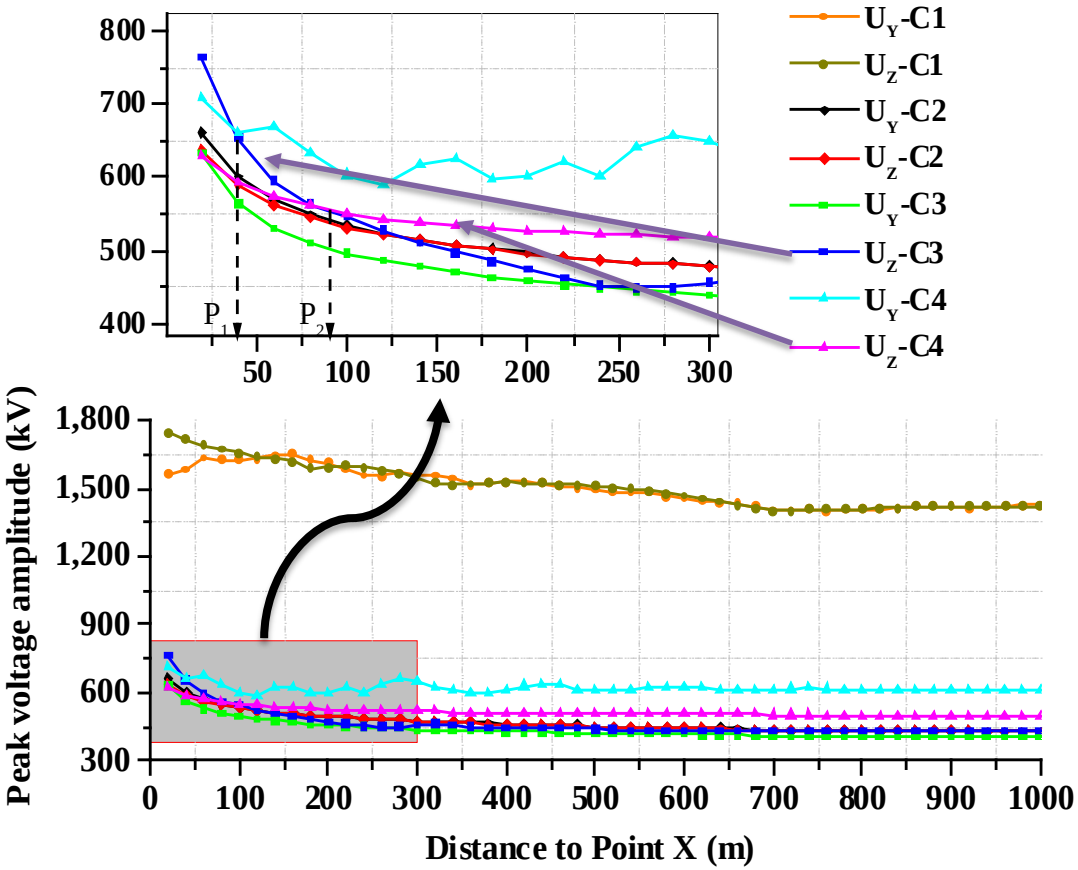

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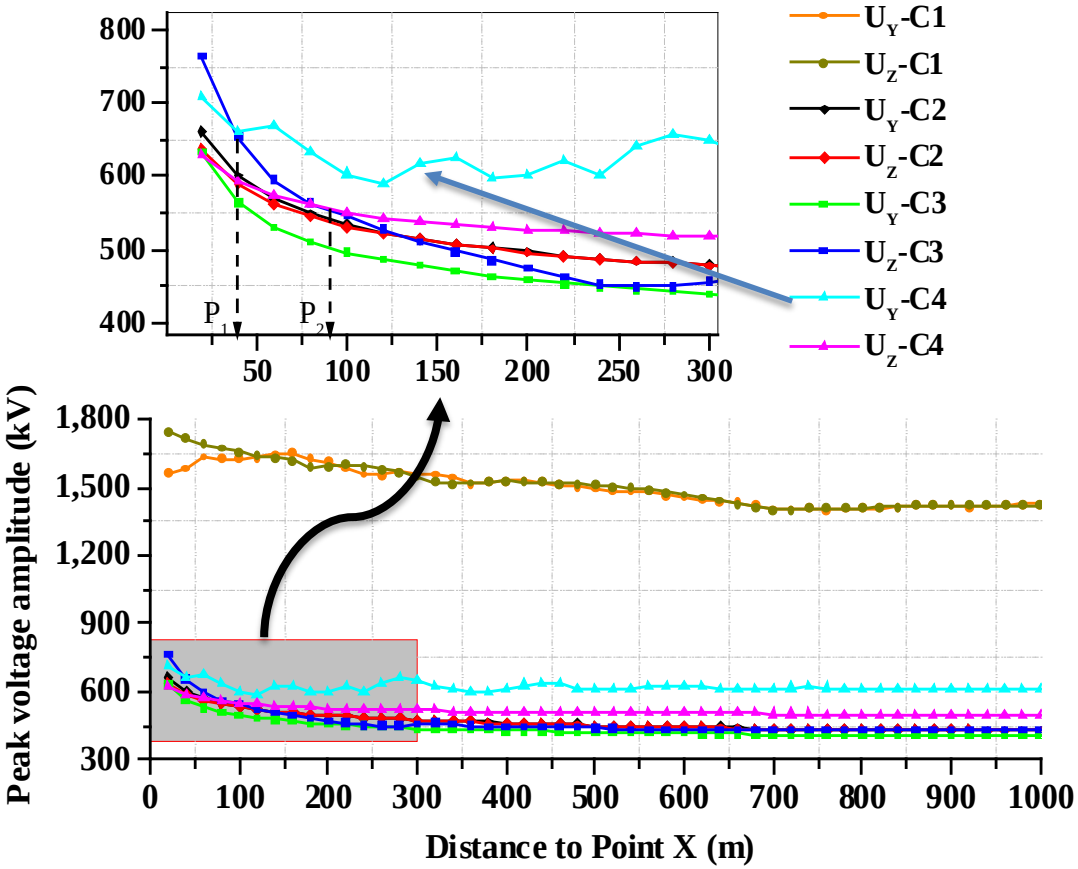

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- C3: $U_Y < U_Z$ C4: $U_Y > U_Z$
- P_1 is the point of intersection of $U_Z - \mathrm{C3}$ *and* $U_Y - C4$
- P_2 is the point of intersection of $U_Z - \mathrm{C3}$ *and* $U_Z - C4$
- $U_Y - \mathrm{C4}$ is always high

U_Y denotes the voltage at the entrance of the substation

U_Z denotes the voltage at the terminal of the transformer

Conclusions

Conclusions

- The **voltage distance curve** provides a good **visual depiction** of the simulation results.
- For most cases, **the overvoltage increases** when the **distance** from the lightning stroke location to the line entrance of the substation **decreases**. Critical points are typically close to the line entrance of the substation.
- Installing surge arresters **either** on the entrance of the substation **or** at the terminal of the transformer are **sufficient** for lighting protection
- Installing surge arrester **only** at the **terminal of the transformer** in the **SRP** 500-230kV substation is proved to be both **adequate** and **efficient** with respect to the lightning performance.

Thank You!

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