ArresterWorks

Lightning Induced Outage Improvement Study for a 115kV Transmission Line

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Prepared for
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Utilities Everywhere

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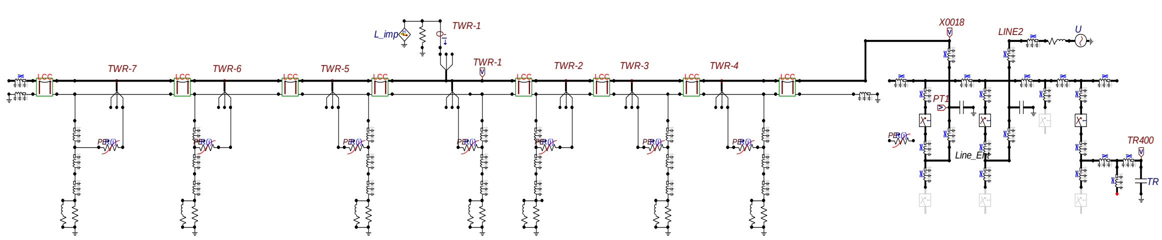

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Summary

Historically, the 63 mile Tuscaloosa-Kingston 115kV transmission line located in the on the Florida-Georgia border has experienced a 8.5 outages/year outage rate. The outages are all caused by lightning striking the system and causing back flashovers of the insulators on the H-frame towers Type AA and BB. Improvements in grounding have shown to be ineffective therefore the utility responsible for this line has commissioned this study to determine the potential improvement through the installation of line arresters and the cost of the same.

The analysis shows that the outage rate can be reduced to zero if arresters are installed on every tower on every phase at a cost of approximately $$$ USD per structure. As an alternative to that the outage rate can be improved dramatically by the strategic application of arresters per the following table.

Tower Type	Arrester Location	Tower Numbers	New Outage Rate	Typical Ground Resistance Ohms	Cost per Mile
AA	Outer Phases only	Every other tower	4.3	80	$$$
BB	Phase away from Shield wire	Every other tower	4.5	80	$$$
BB	Arresters on Outer Phases	Every other tower	4.5	80	$$$
BB	Phase away from Shield	Every tower	2.1	80	$$$

Overall Conclusions of the Study

End of Summary

Bases for the Analysis

All insulation will flashover or puncture in the presence of surges with amplitudes and durations above the limit of the design. This study was commissioned to determine the effectiveness of the strategic application of arresters along the 63 mile Tuscaloosa-Kingston 115kV transmission line located in the on the Florida-Georgia border This analysis was done with extensive use of the IEEE excel based Flash program, and the well-known Transient Analysis Program (ATP). The main references for this study are IEEE 1313.2 [2], IEEE C62.22 [3] and Andrew Hileman's book [1], ATPDraw Users Manual, and EMTP Rulebook.

Scope of Work

Tower Performance

- Determine the performance of each tower type
- Determine the effect of ground impedance on the tower performance
- Determine the effect of arresters on the tower performance

Arrester Selection and Installation

- Summarize the potential arrester model numbers that can be used.
- Offer recommendations on installation configurations and hardware necessary

Methods of Analysis

This analysis is completed in several steps.

1. Line and Tower Data Collected.
    a. Insulation dimensions
    b. Tower Dimensions
    c. Ground resistances
    d. Conductor Sizes
    e. Span distances
    f. Ground Flash Density of area
    g. Tower Material
    h. Down Conductor Characteristics

2. The Line and Tower are modeled in IEEE Flash where the flashover rate is determined
3. The Line and Tower are Modeled in ATPDraw and several runs are completed to determine agreement with Flash.
4. Model the Line and Tower are modeled with arresters installed at different locations.
    a. The effect of arresters under various locations and mounting configurations
    b. The effect of arrester rating
    c. The effect of lightning on the arrester
        i. Energy handling
5. From results of the study arrester model numbers from various suppliers are identified.
6. From results of study, mounting hardware is selected and recommended.
7. Budgetary figures are derived from results of study and supplier inquires.
8. Report is issued on all the above
9. The report is presented on line for Q&A of customer

Tower Characteristics

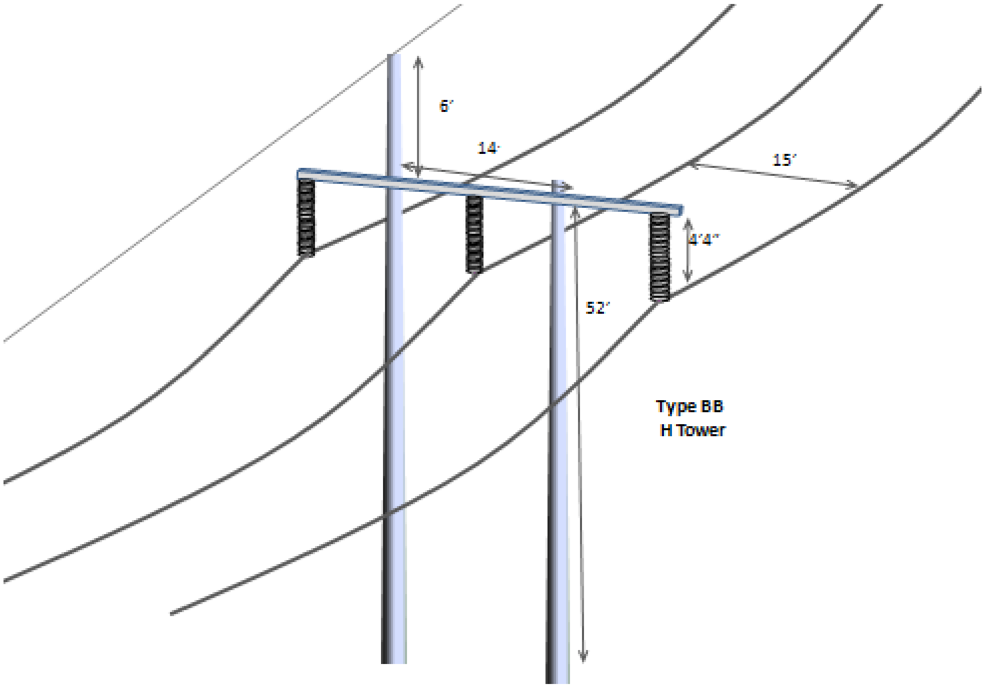


Figure 1 Tower Type BB

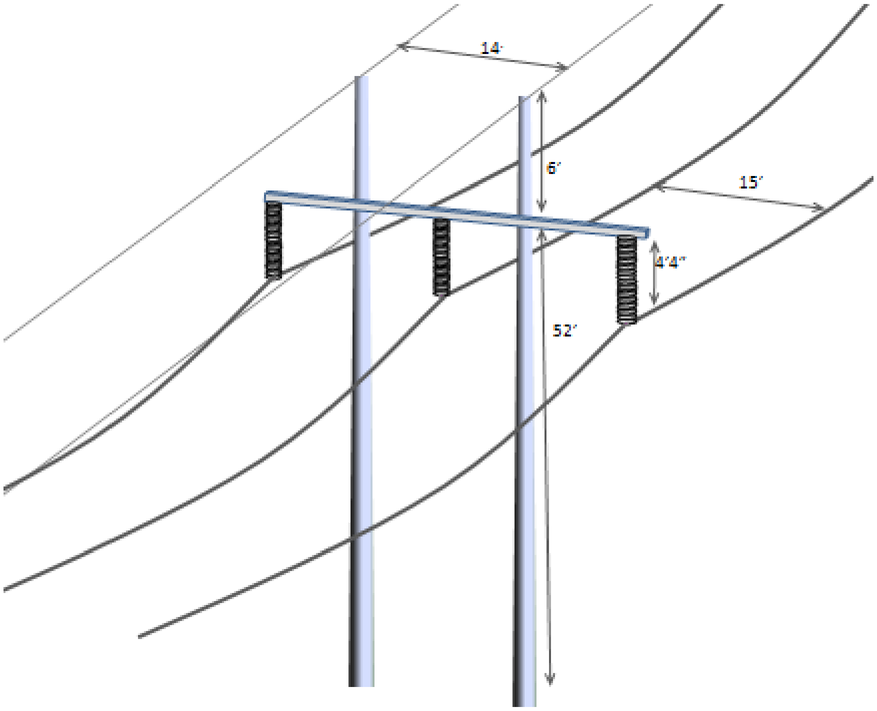


Figure 2 Tower Type AA

Analysis

IEEE Flash Analysis

Title	Tower AA	Program Path	d:\flash\flash.exe
GFD [per sq mi]	4	Scratch Input File	d:\flash\testxl.dat
Span [ft]	300	Scratch Output File	d:\flash\testxl.out

English Units | Metric Units | Run

Conductors

Diameter [in]	1.25	# Bundled	1			
Sag [ft]	2.1	Spacing [in]	0			

Index	X [ft]	Y [ft]	SI [ft]	kV	Angle	AC/DC?
1	-15	47.75	4.25	115	0	ac
2	0	47.75	4.25	115	120	ac
3	15	47.75	4.25	115	240	ac
4						
5						
6						
7						
8						
9						
10						
11						
12						

Shield Wires

Diameter [in]	0.5	
Sag [ft]	1	
Index	X [ft]	Y [ft]
1	-7.5	58
2		

Exposed Conductors / **Shielding Angles**

Index	Conductor	Shield Wire	Required	Actual
1	2	1	-38.23	-34.32
2	3	1	-38.23	63.98
3				
4				

Footing Resistances

Percentage (*)	Ohms
50	50
50	50

Check Sum: 100

(*) can use percentage, number of towers, or line segment lengths

Flashover Rates

Backflash	6.17	/100 mi/yr
Shielding Failure	6.61	/100 mi/yr
Total	12.78	/100 mi/yr

Tower Model 2 - H Frame

Height	58	[ft]
Lead Diameter	0.1	[ft]
Lead Separation	0.1	[ft]
-not used-	4.5	[ft]
-not used-	7.07	[ft]

Do Not Edit:
1 - Cone
2 - H Frame
3 - Cylinder
4 - Waist

Version 1.9 - May 2007

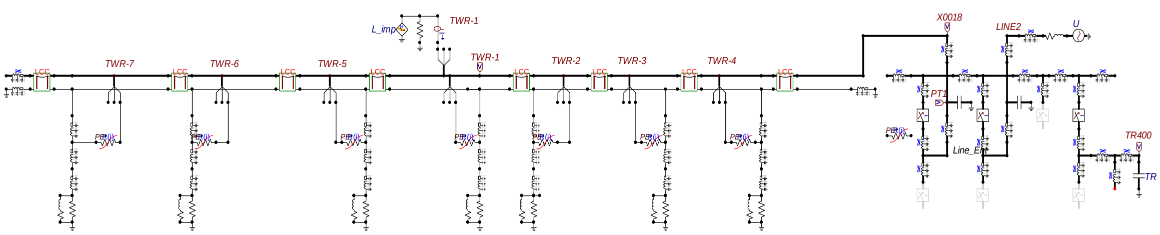
Flash Results

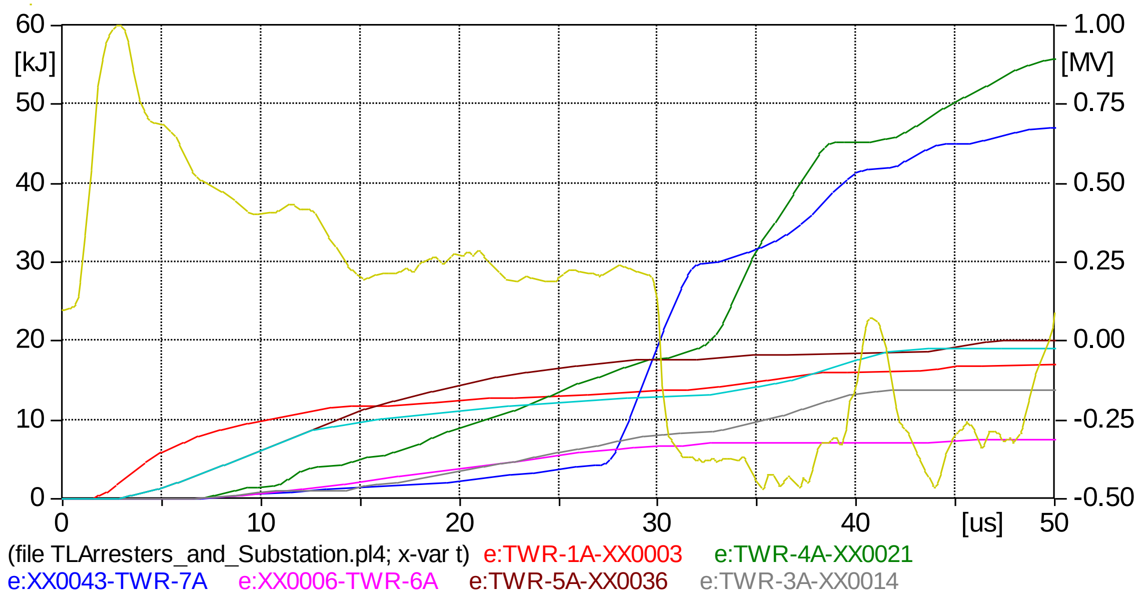
The flashover rate of a Type BB Modified H-frame tower is 12.76/100 miles per year. Half of that is from shielding failure and half from back flash. This is 8.03 flashovers for the 63 mile line.

For the ATP results, 3.99 impulses will be directed to the unshielded conductor as well as the ### to the shield.

ATP Analysis

A seven pole segment of the line was analyzed to determine the energy handling capability requirements of arresters connected to the outside unprotected phase. The results show that a standard Class 1 arrester has adequate energy handling capability.





End of Main Body

See Summary at the Beginning of the report for the final Summary and Conclusions

References

[1] Hileman, A.R., *Insulation Coordination for Power Systems*, Marcel Dekker, Inc., New York, 1999, ISBN 0-8247-9957-7.

[2] IEEE Std 1313.2-1999 (R2005) *IEEE Guide for the Application of Insulation Coordination*, Institute of Electrical and Electronic Engineers, New York, 1999

[3] IEEE Std C62.22-2009 *IEEE Guide for the Application of Metal Oxide Surge Arresters for Alternating-Current Systems*, Institute of Electrical and Electronic Engineers, New York, 2009

[4] G.W. Brown, “Designing EHV Lines to a given outage rate - Simplified Techniques,” IEEE Transactions on PA&S, March 1978 Pg 379-383.

[5] IEEE Std C57 12 00 - 2006 *IEEE Standard for Standard General Requirements for Liquid-Immersed Distribution, Power, and Regulating Transformers* Institute of Electrical and Electronic Engineers, New York, 2006

[6] ATP Draw Users Manual Rev 5.6

[7] EMTP Rule Book 1981