Mitigating Interference on Cathodically Protected Pipelines

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Presentation Objectives

The purpose of this presentation is to explain the effects transmission lines may have on adjacent pipelines and provide an example of a voltage controlled decoupling device to mitigate pipeline overvoltages without affecting existing pipeline cathodic protection. At the end of this presentation you will be able to:

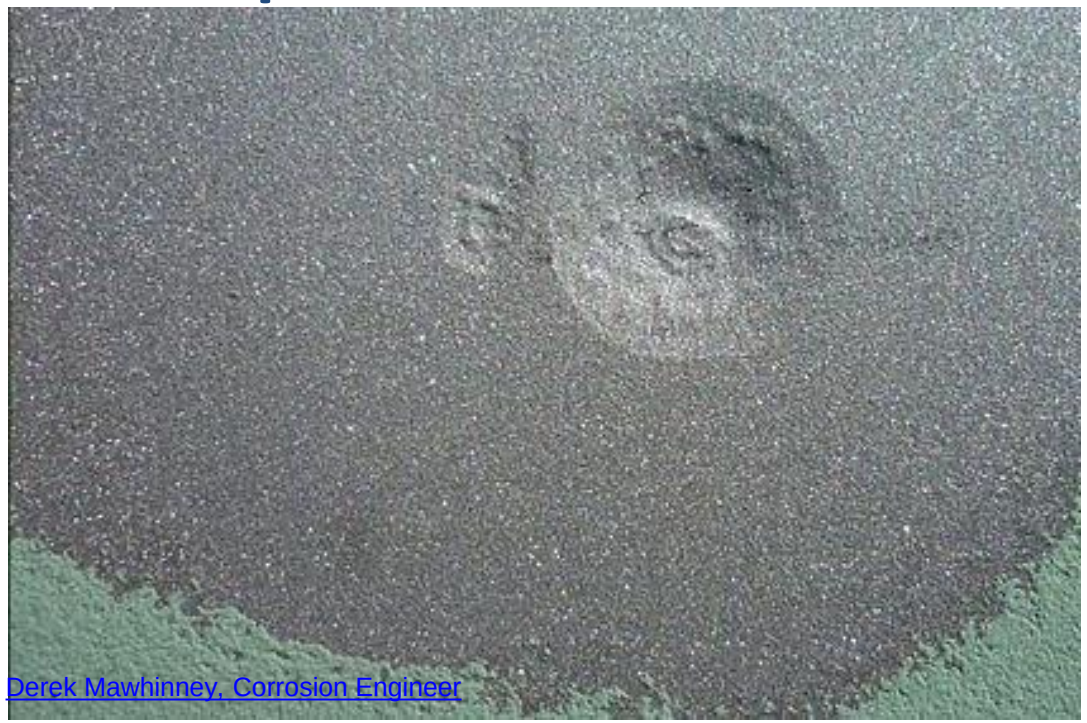
- Explain the effects a transmission line may have when in a share corridor with a pipeline
- Describe the multiple stresses protective and mitigating equipment must withstand
- Develop a process for evaluating mitigating tactics

Outline

- Pipelines hazards when in shared corridors
- Pipeline components
- Mitigation goals and options
- Case study

Steady State Hazards for Pipelines

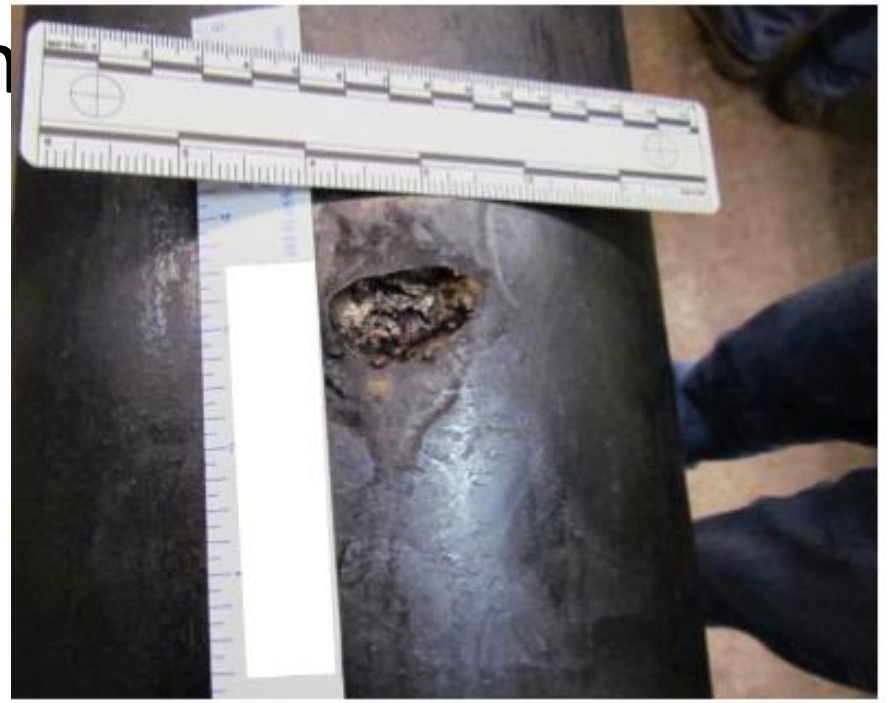
- Personnel Hazards
  - Touch Voltage (15 V - 50 V)
- Pipeline & Equipment
  - AC Corrosion via holiday
    - 30 A/m^2



Derek Mawhinney, Corrosion Engineer

Fault State Hazards for Pipelines

- Personnel Hazards
  - IEEE Std 80 Touch
- Pipeline & Equipm
  - Coating Stress
  - Arcing



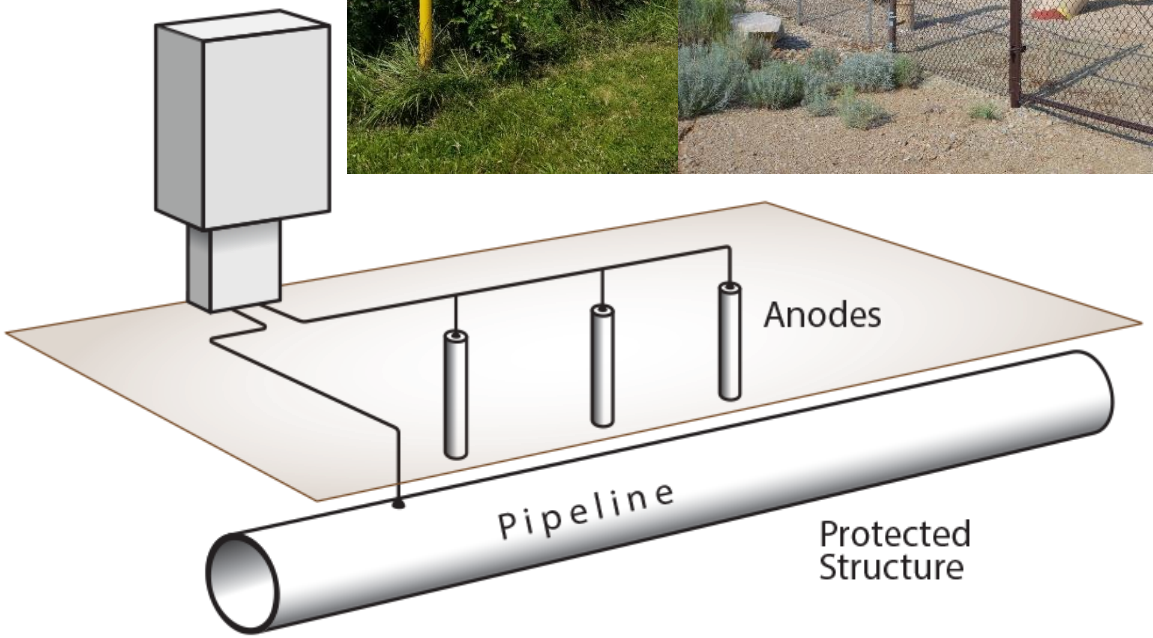
Lightning Hazards for Pipelines

- Perso
  - IE
- Pipel
  - Co
  - Ar

PIPELINE PROTECTION

Pipeline Components

- Appurtenance
  - Pump station
  - Test site
  - Valve
- Material
- Coating
- Cathodic Protection
  - Passive
  - Impressed Current



Mitigation Goals

- Protect personnel
- Protect pipeline insulation
- Protect pipeline components

Mitigation Approaches

- Grounding
- Gradient control mat
- Insulated joints
- Non-conductive barriers
- PPE

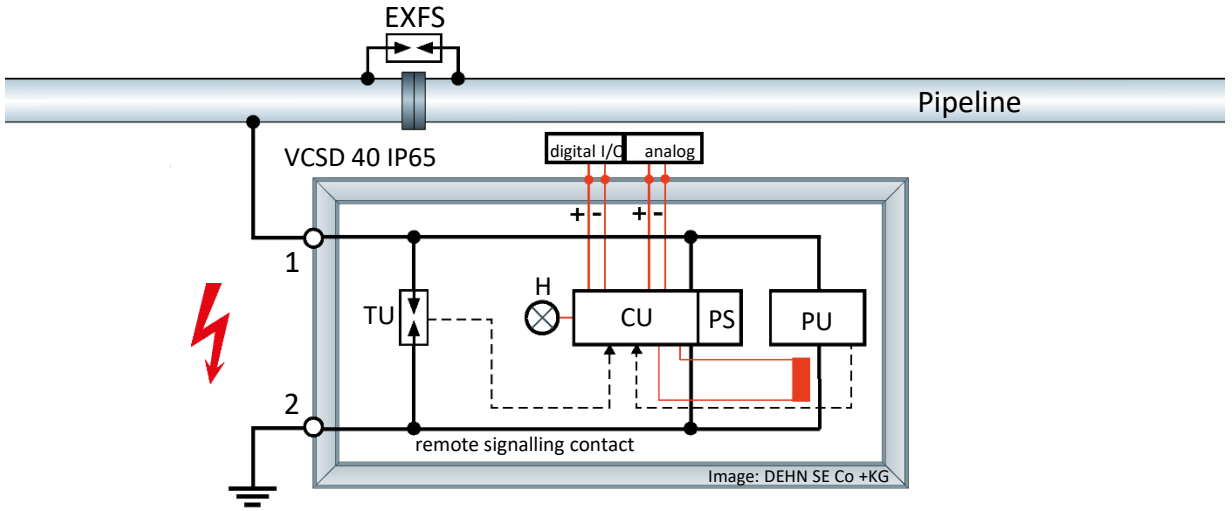
Cannot Directly Connect to Pipelines with Impressed Current

Understanding Decoupling Devices

The aim of decouplers are to:

- Minimize voltage differences by instantaneously bonding metallic parts together during:
  - AC Interference
  - Electrical faults
  - Lightning Strikes

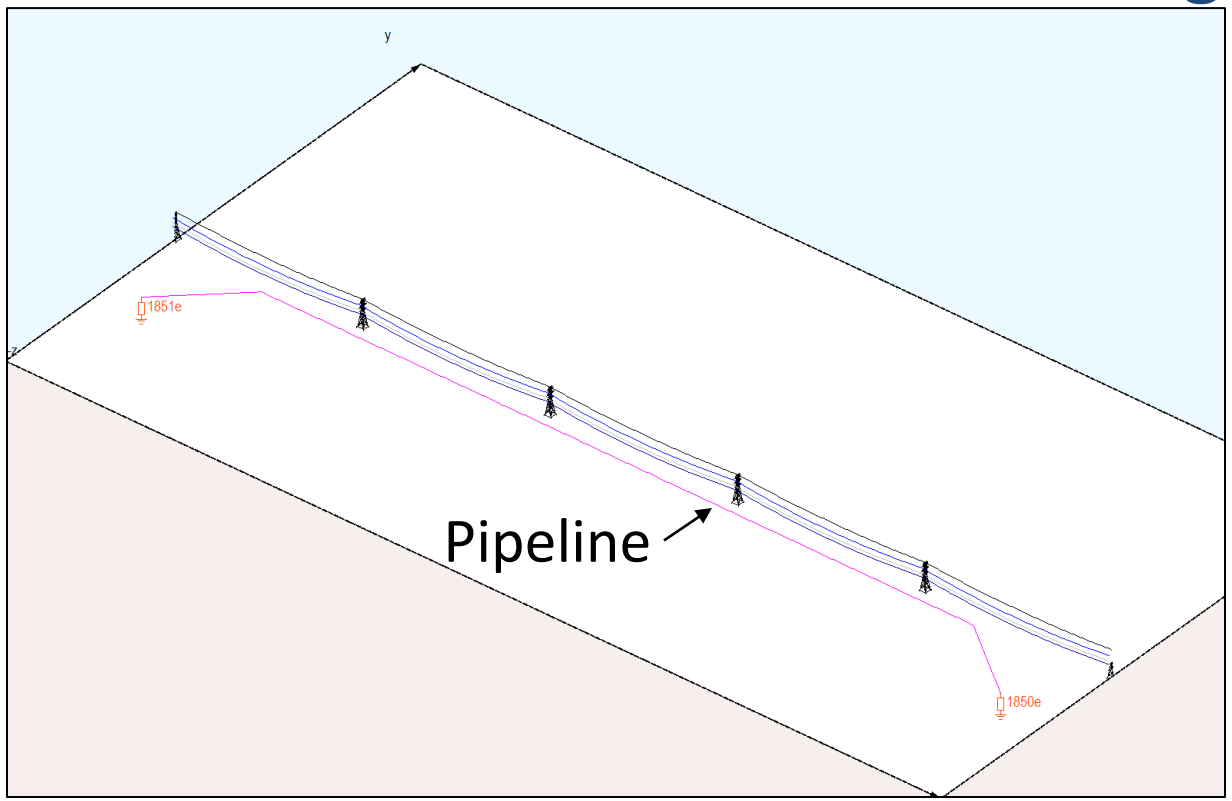

Image: DEHN SE Co +KG



TU:	Transient Unit	PU:	Power Unit
CU:	Control Unit	EXFS:	Isolated spark gap for use in hazardous areas
PS:	Power Supply		

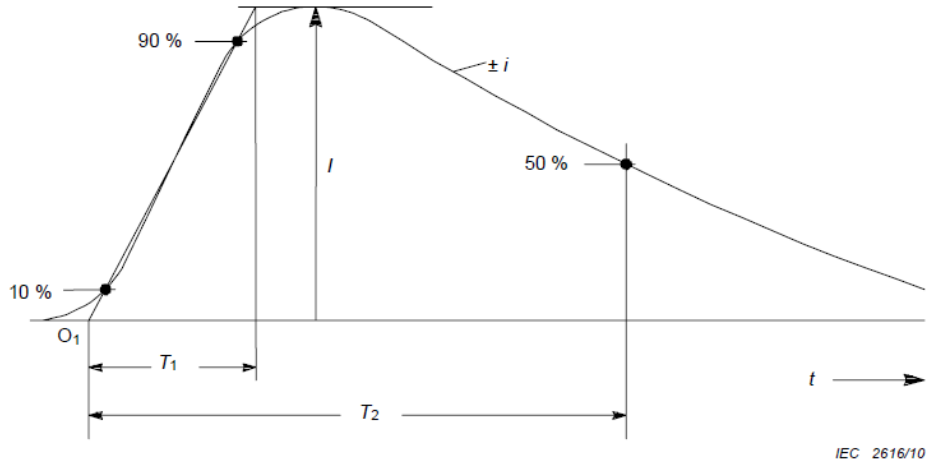
CASE STUDY

Background



- 345 kV Line
  - Max Loading 500 A
  - Fault Current 30 kA
  - First Negative: 100 kA 1/200 µs
- Pipeline
  - 16” Steel
  - Polyethylene Coating
  - Buried depth 4 feet
  - 50 ohm-m soil

Background



Key

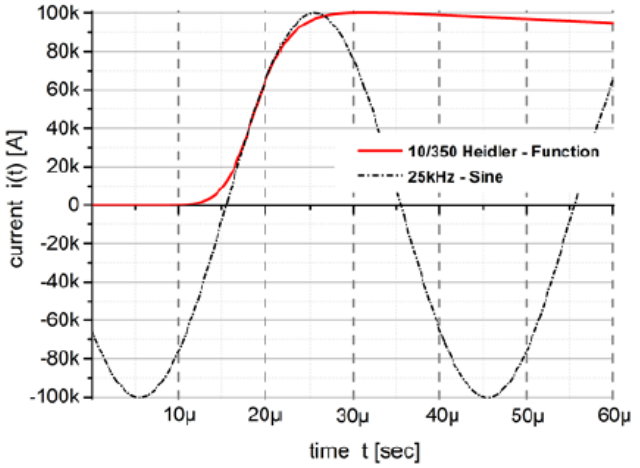
O_1 virtual origin

I peak current

T_1 front time

T_2 time to half value

Figure A.1 – Definitions of impulse current parameters (typically T_2 < 2 ms)

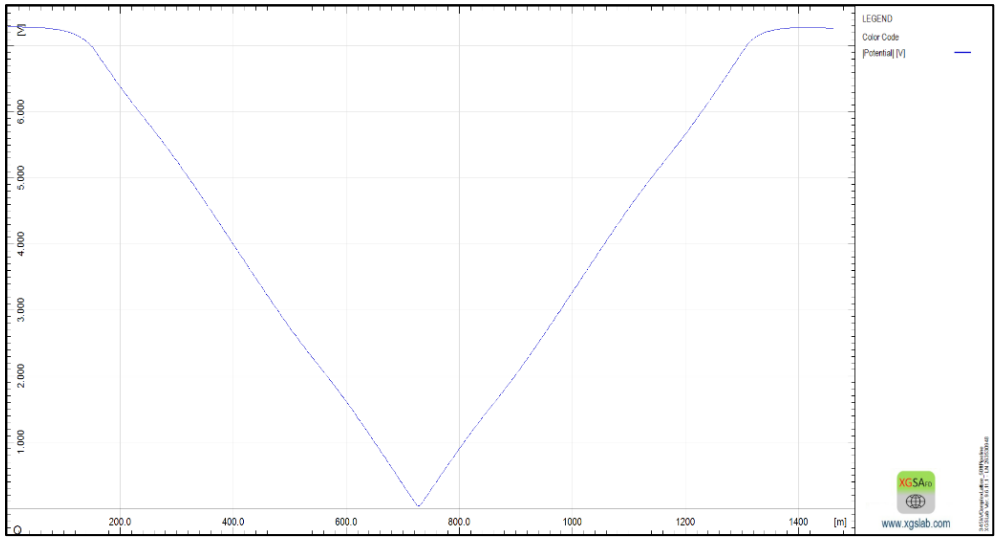


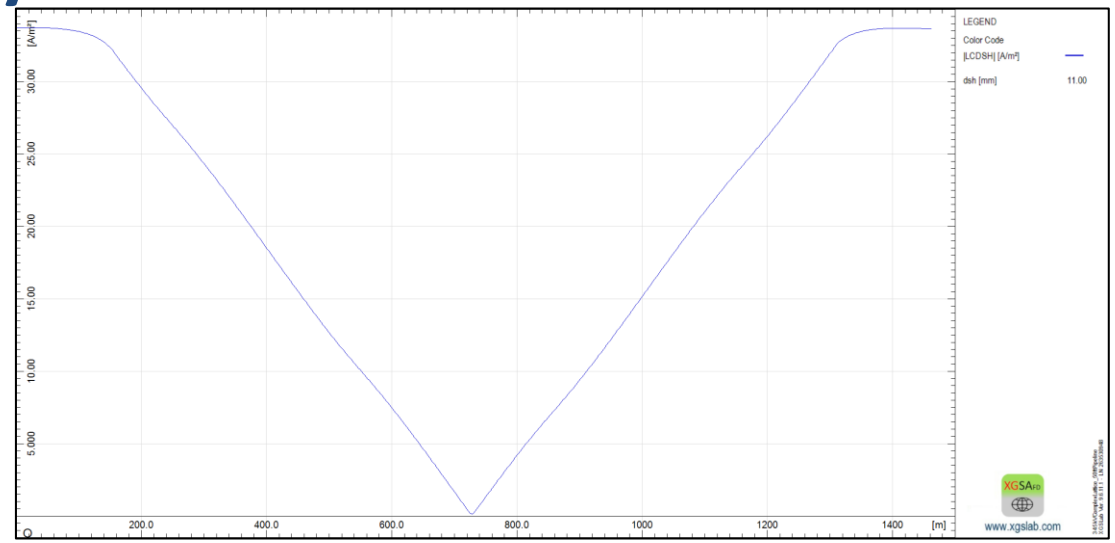
Type of short stroke	IEC 62305-1 parameters						Impulse parameters		Equivalent frequency
	I Class I (kA)	I Class II (kA)	I Class III-IV (kA)	k	T1 (µs)	T2 (µs)	T1 (µs)	T2 (µs)	f (kHz)
First positive	200	150	100	0.93	19	485	10	350	25
First negative	100	75	50	0.986	1.82	285	1	200	250
Subsequent negative	50	37.5	25	0.993	0.454	143	0.25	100	1000

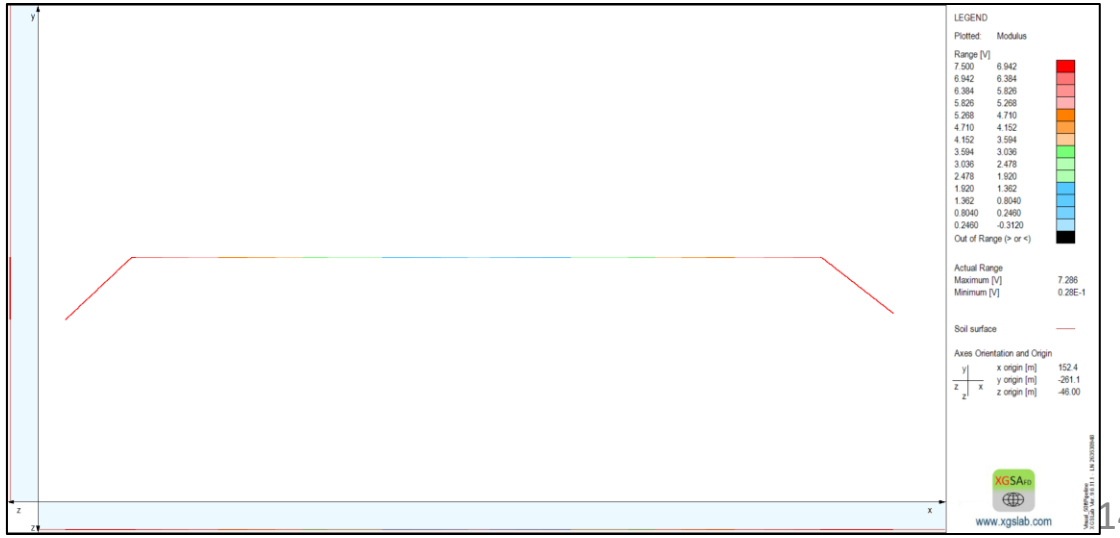
Ref: J. Meppelink, R. Andolfato and D. Cuccarollo, "Calculation of Lightning Effects in the Frequency Domain," in *International Colloquium on Lightning and Power systems*, Bologna, 2016.
IEC 62305: 1

Steady State

- Pipeline 7.27 V
- AC Corrosion 33.7 A/m^2

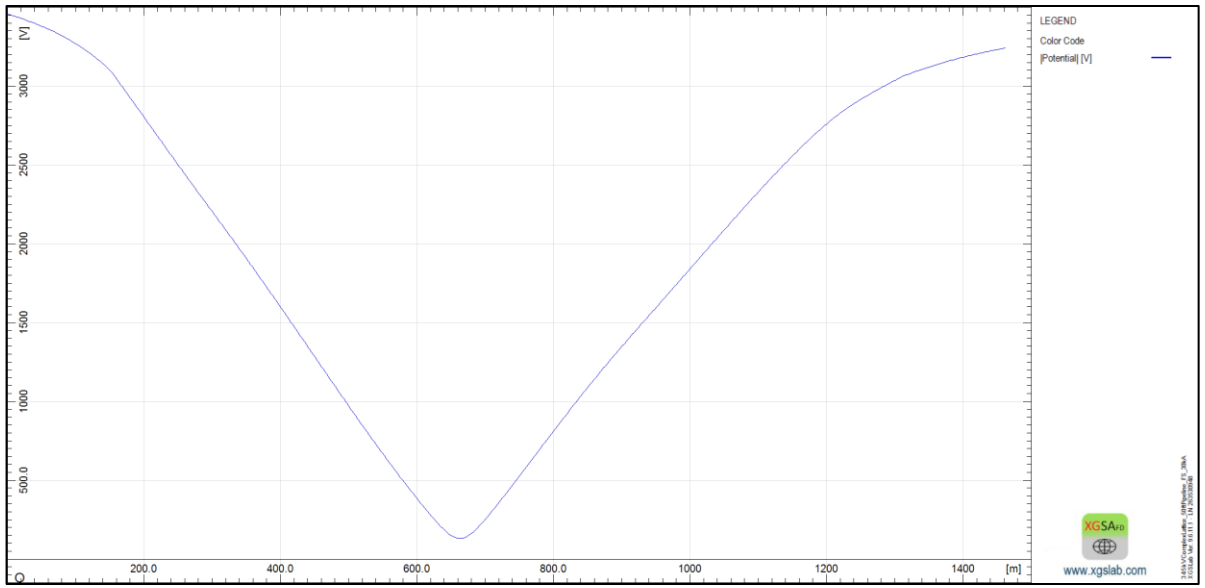


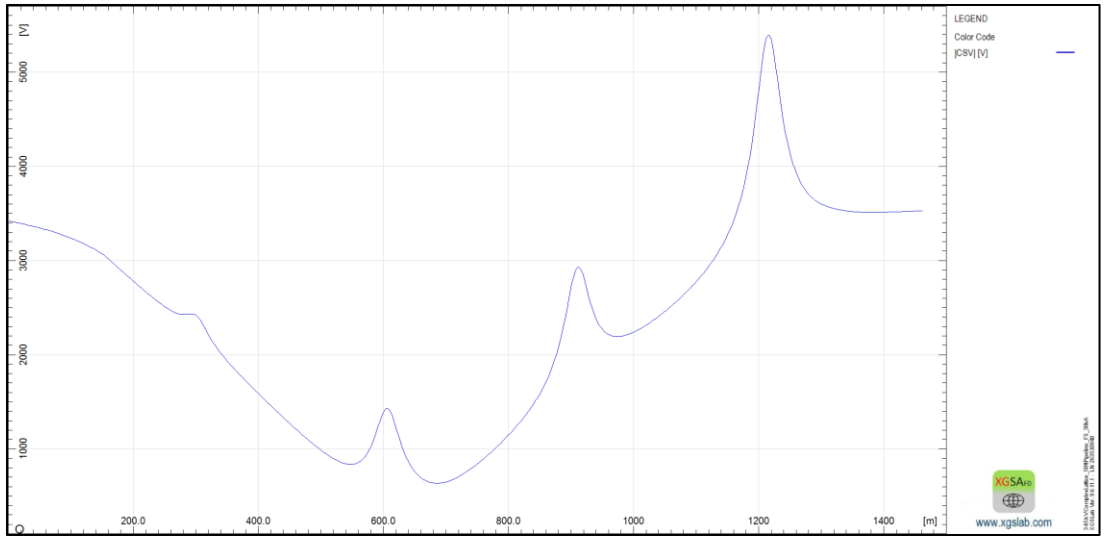




Fault State

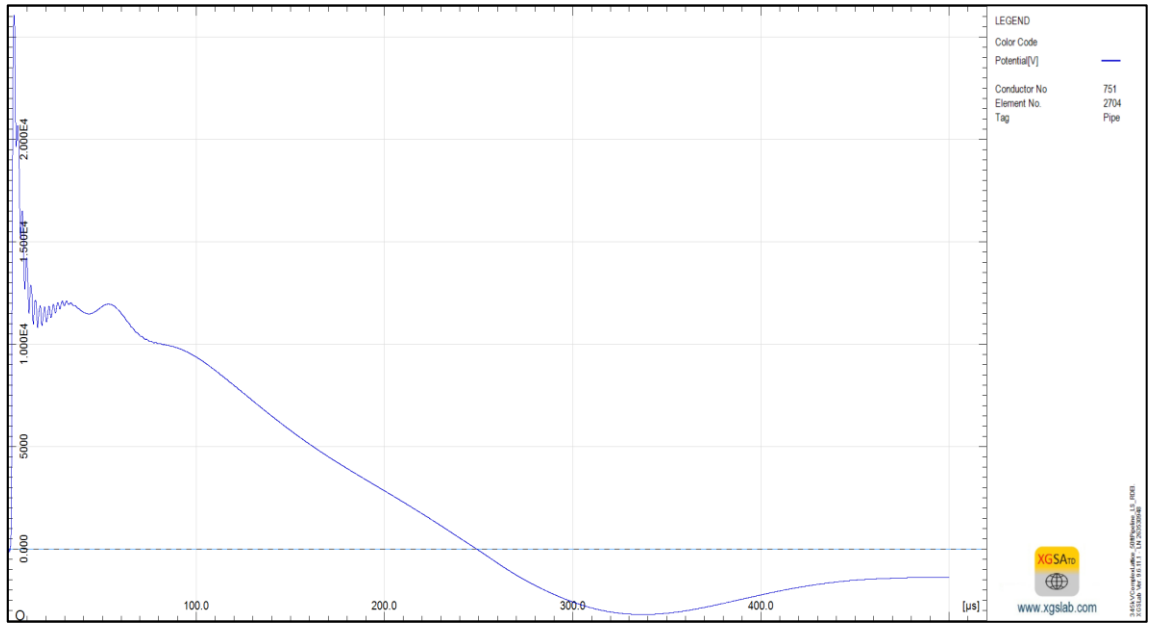
- Pipeline 3.4 kV
- Coating Stress 5.4 kV

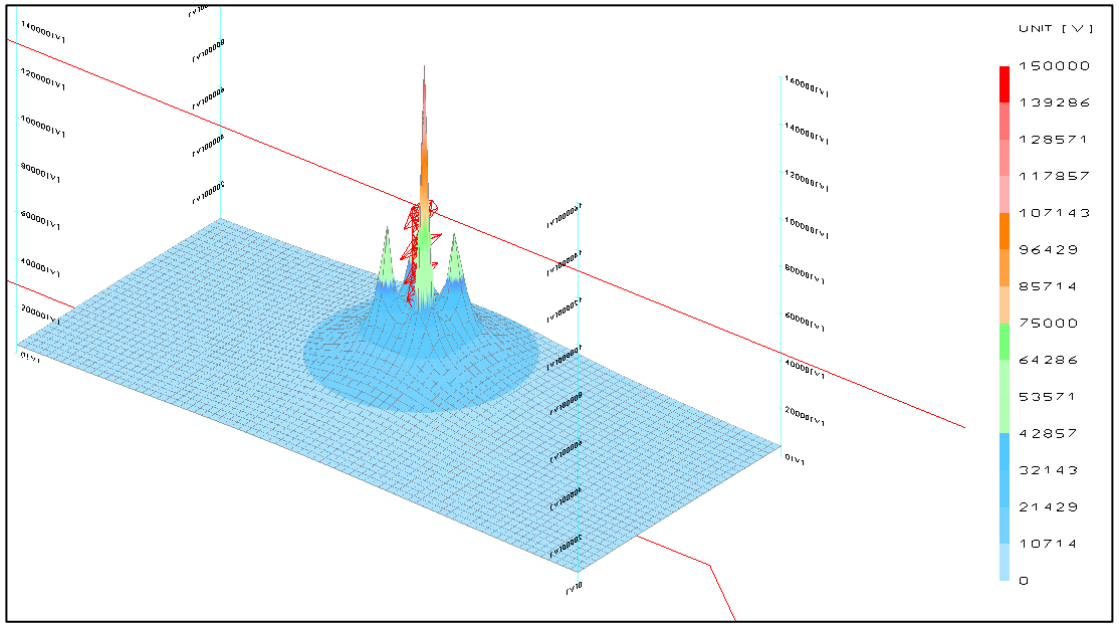




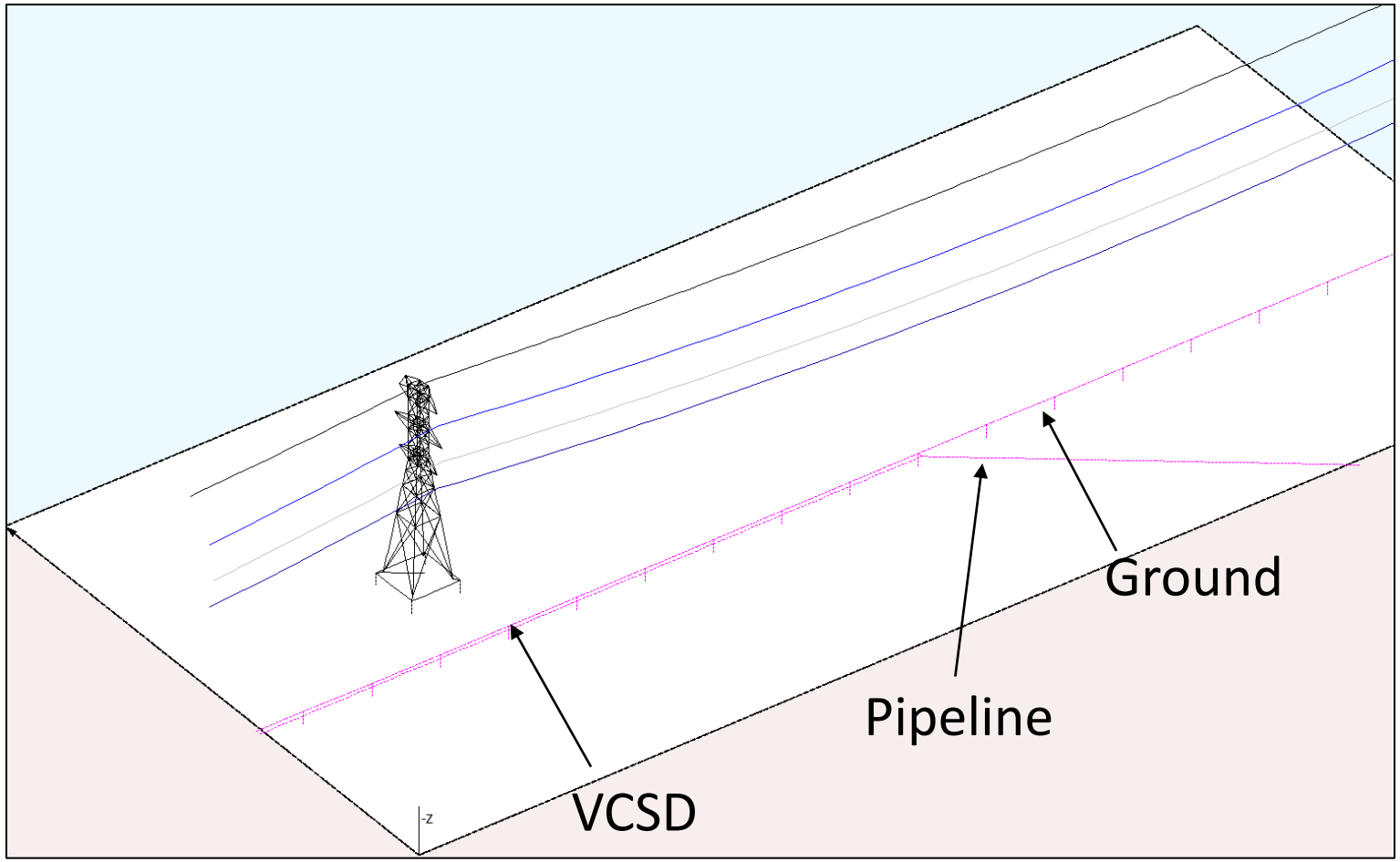
Lightning State

- Pipeline 26.0 kV
- Coating Stress 16.1 kV



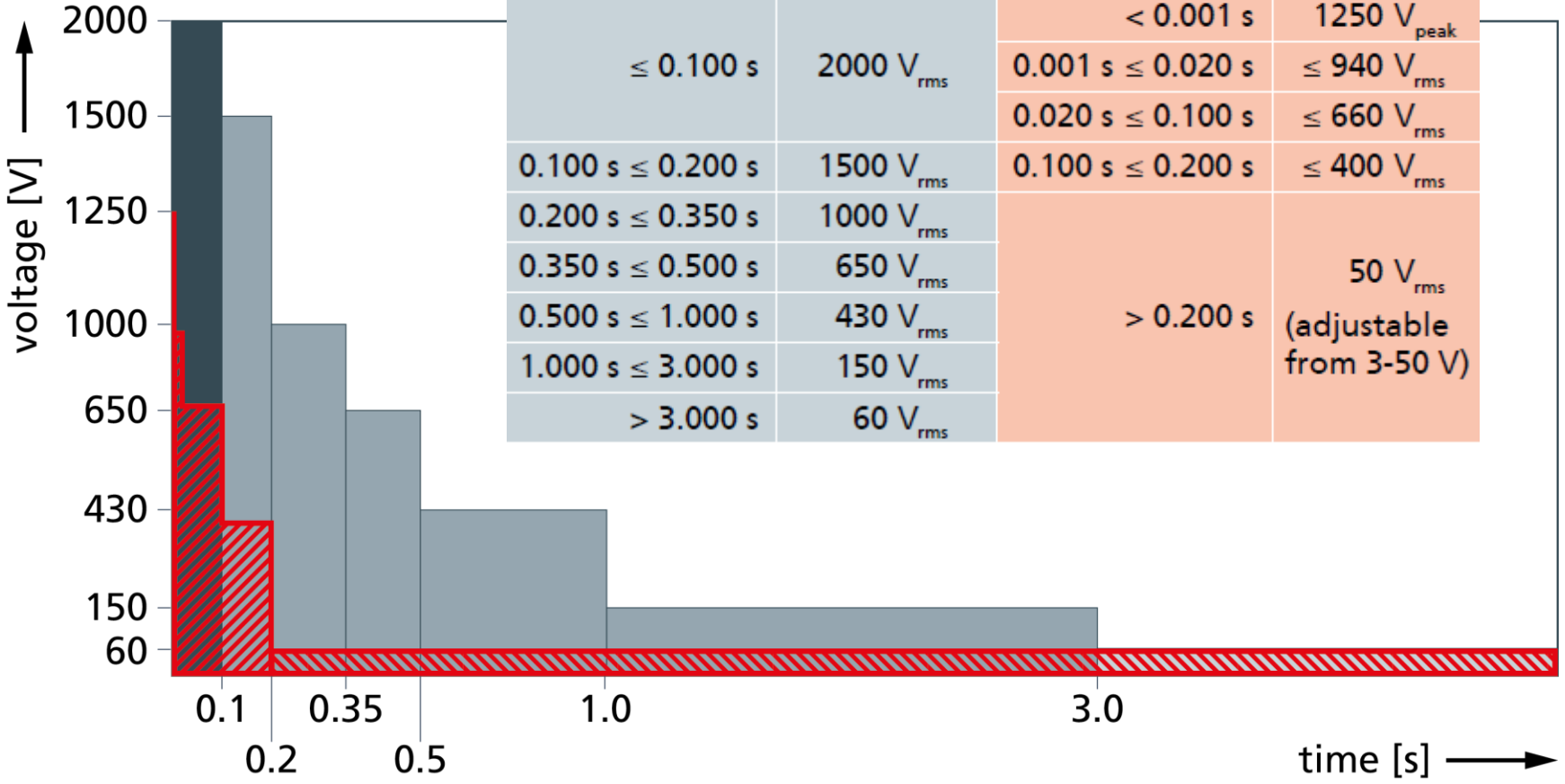


Applying Mitigation



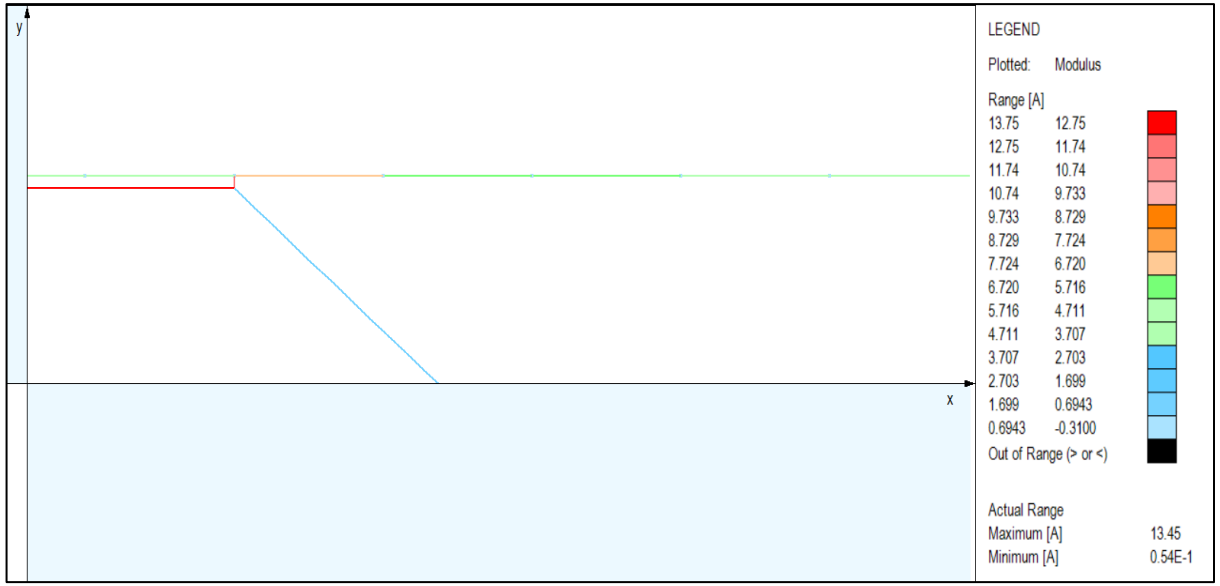
Applying Mitigation

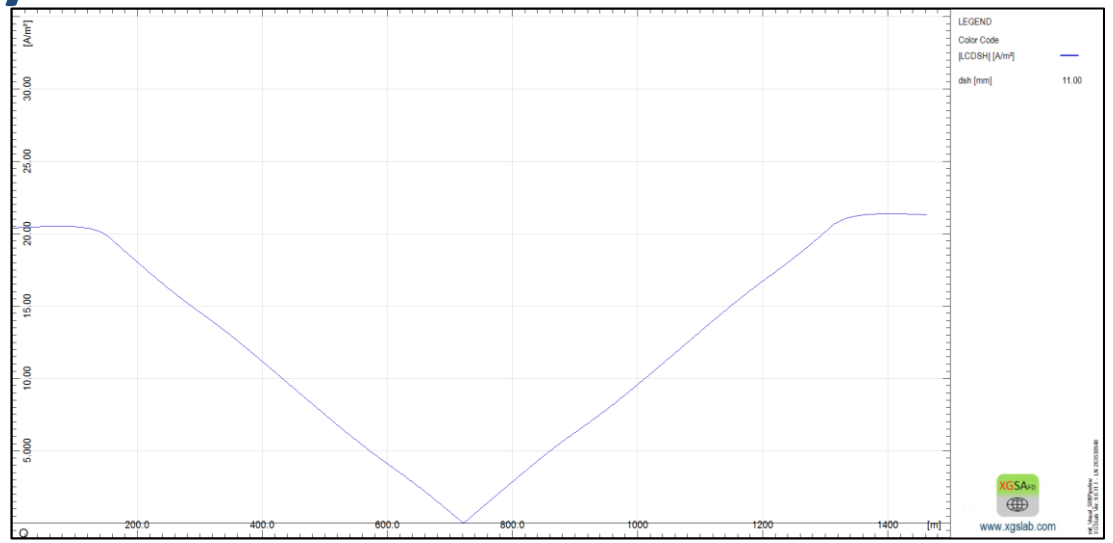
Voltage limits acc. to EN 50443		Performance of VCSD 40 IP65	
fault duration	interference voltage	operating time	limiting voltage
≤ 0.100 s	2000 V_{rms}	< 0.001 s	1250 V_{peak}
		0.001 s ≤ 0.020 s	≤ 940 V_{rms}
		0.020 s ≤ 0.100 s	≤ 660 V_{rms}
0.100 s ≤ 0.200 s	1500 V_{rms}	0.100 s ≤ 0.200 s	≤ 400 V_{rms}
0.200 s ≤ 0.350 s	1000 V_{rms}	> 0.200 s	50 V_{rms} (adjustable from 3-50 V)
0.350 s ≤ 0.500 s	650 V_{rms}		
0.500 s ≤ 1.000 s	430 V_{rms}		
1.000 s ≤ 3.000 s	150 V_{rms}		
> 3.000 s	60 V_{rms}		



Steady State

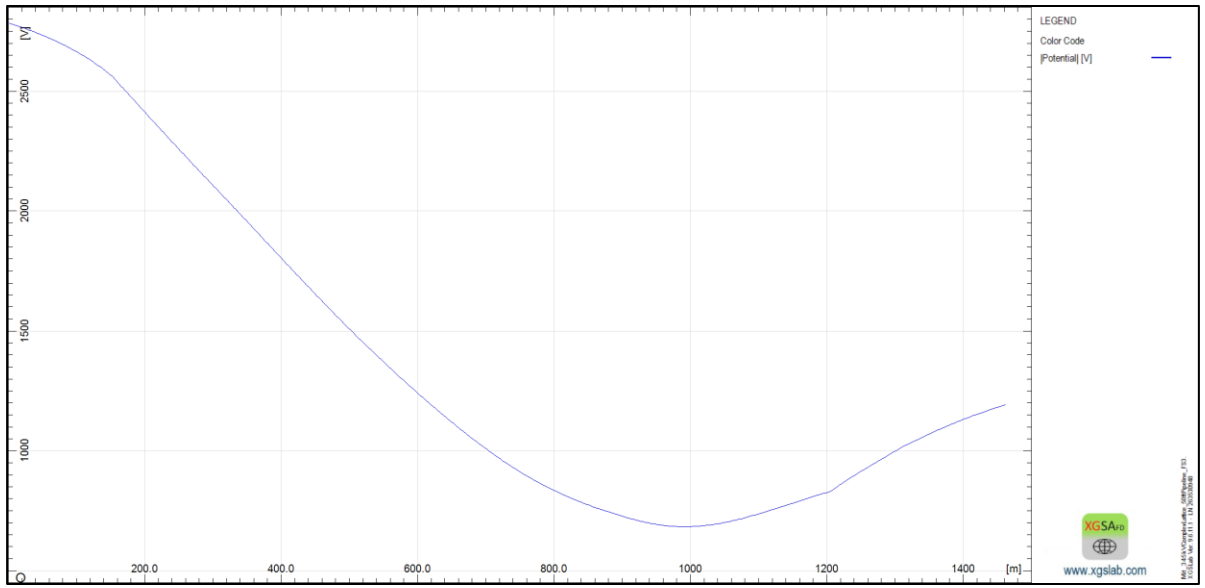
- VCSD 12.6 A
- AC Corrosion 20.5 A/m²

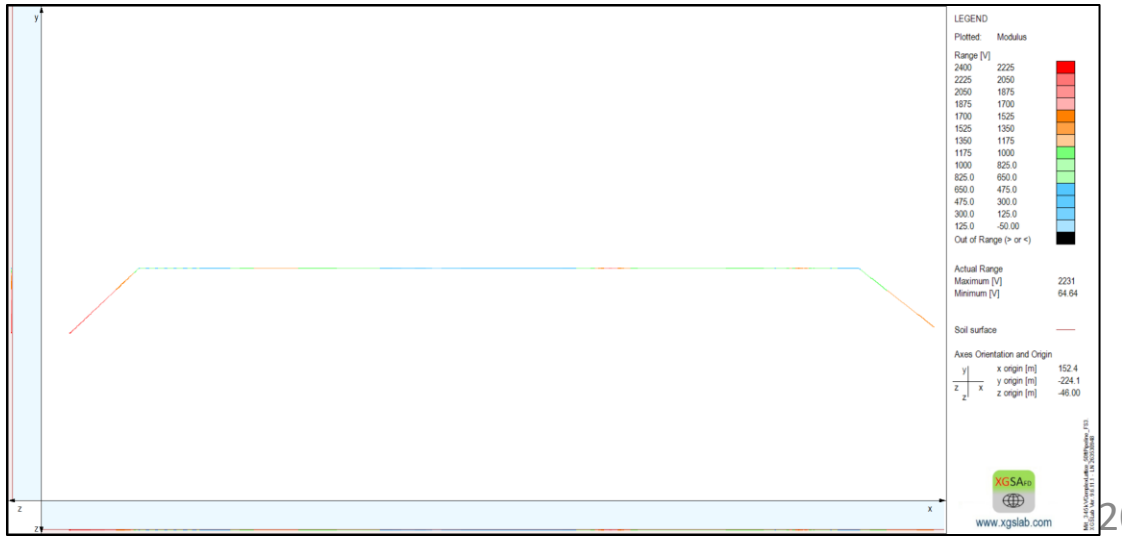




Fault State

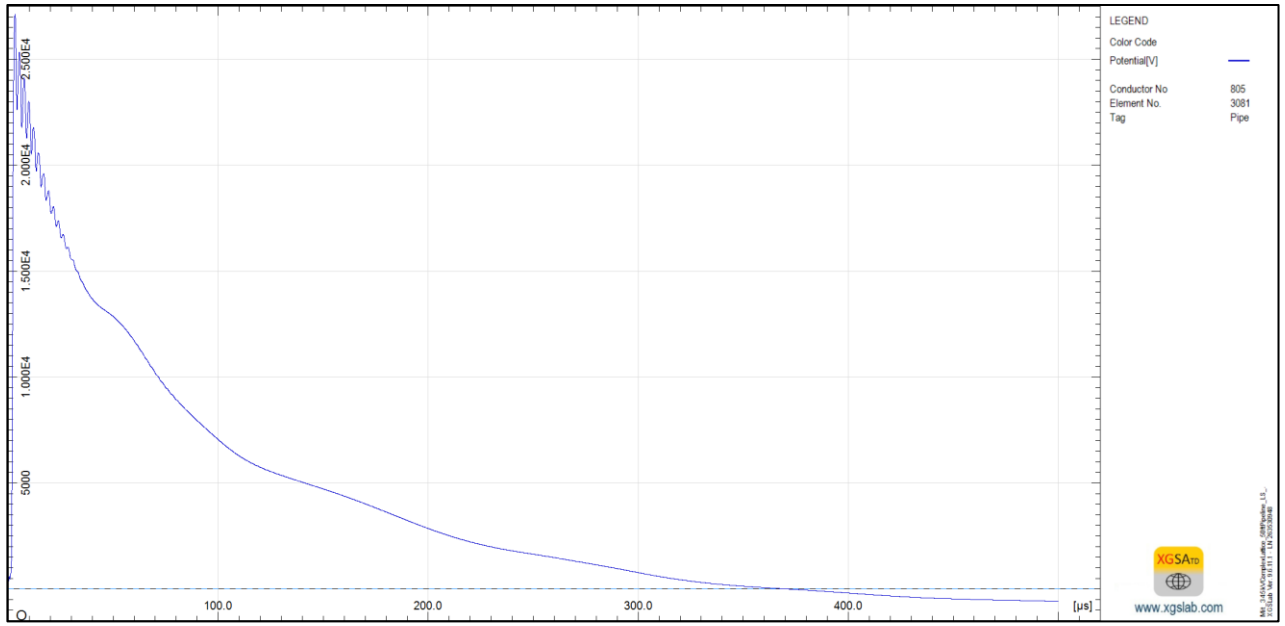
- VCSD 6.1 kA
- Pipeline 2.8 kV
- Coating Stress 2.2 kV

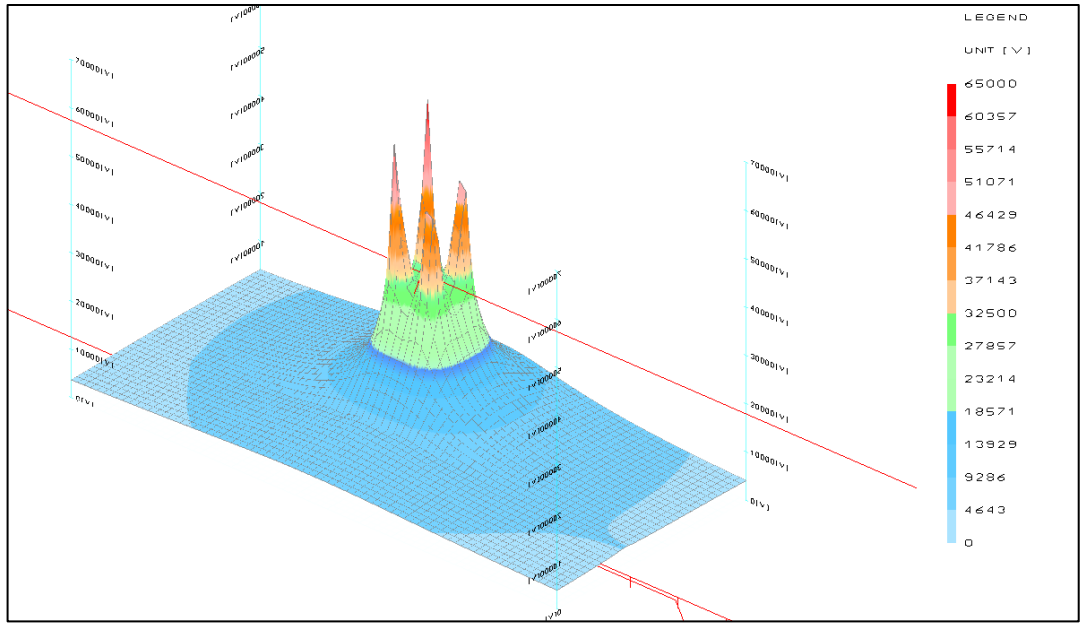




Lightning State

- VCSD 1.6 kA (396 I^2S)
- Pipeline 26.7 kV
- Coating Stress 3.1 kV





Conclusion

- Effects of a transmission line near pipelines with impressed cathodic protection are complex analysis
- Mitigation strategies should be analyzed to withstand application
- For future studies, the following should be explored:
  - The charge (A/s) rating of the pipeline to investigate when the pipe wall will be punctured
  - Maximum distance from protected pipeline to mitigating ground that decouplers provide protection