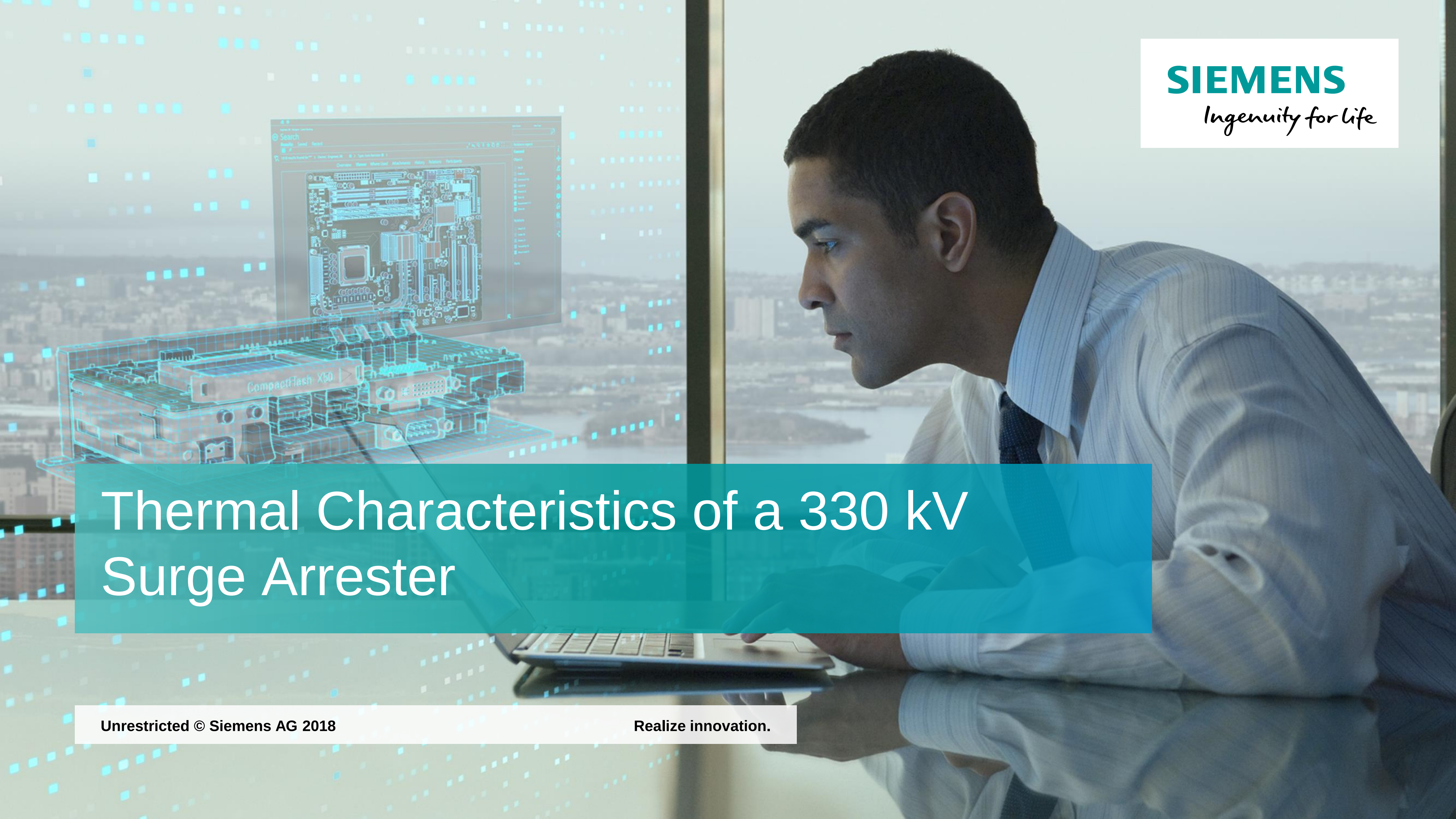
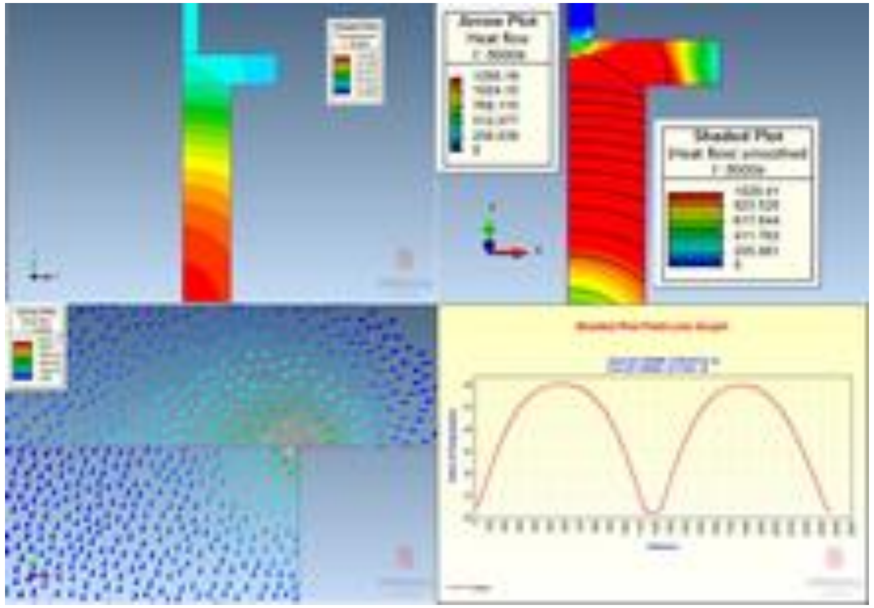


Thermal Characteristics of a 330 kV Surge Arrester

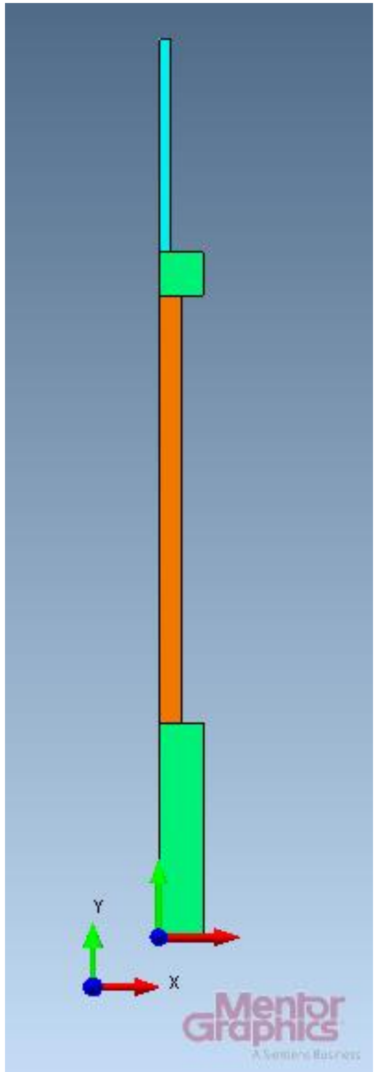
Thermal Characteristics of a 330 kV Surge Arrester



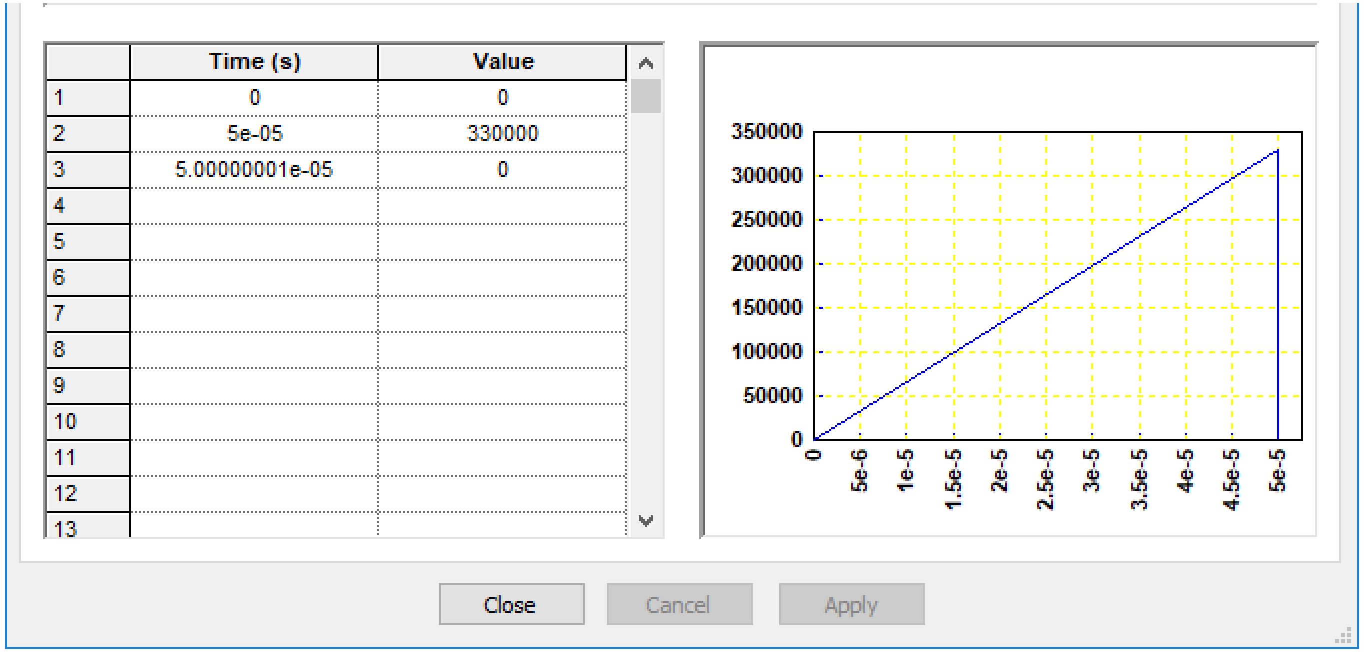
Surge arresters are used in a number of industries as protective devices against a variety of electrical events such as high-voltage lightning impulses. The design choices of various materials and components for lightning arresters may depend on their thermal characteristics, among many other factors. To demonstrate this, the thermal analysis of a 330 kV metal-oxide arrester is considered in this example. The adiabatic heating of the varistor due to a lightning strike, and the subsequent temperature distribution in the device as a function of time, are presented here.

SURGE ARRESTER MODEL

A simple surge arrester comprising various essential components is shown in this figure. The base, metal-oxide varistor, spacer, and electrode are clearly identified in the model.



MODELING A LIGHTNING IMPULSE

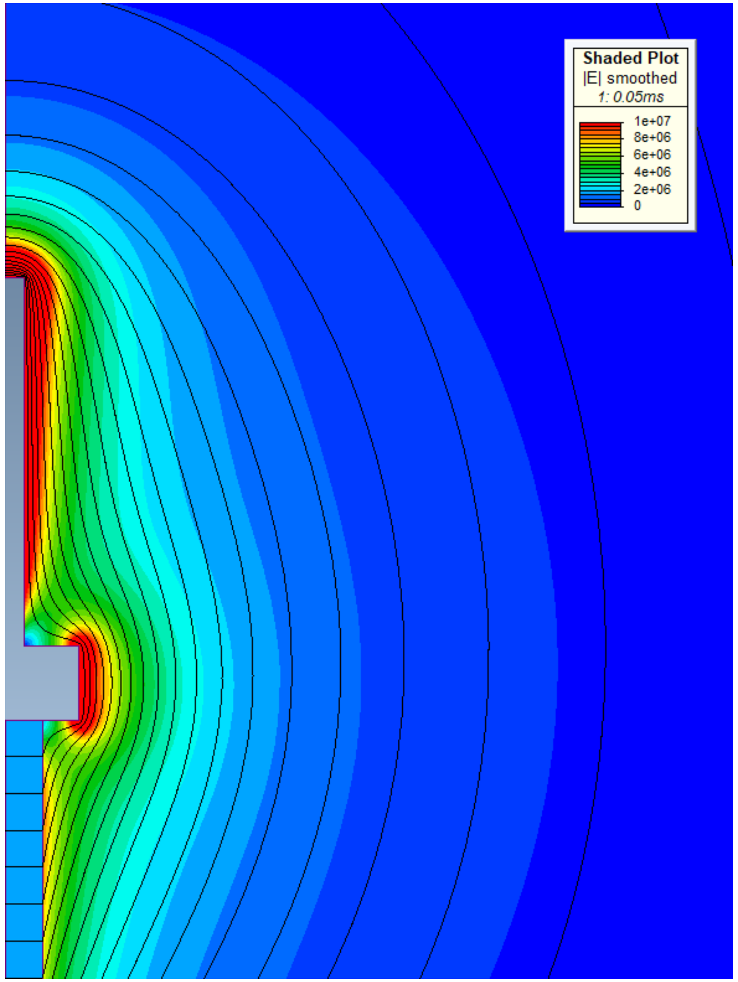


	Time (s)	Value
1	0	0
2	5e-05	330000
3	5.00000001e-05	0
4		
5		
6		
7		
8		
9		
10		
11		
12		
13		

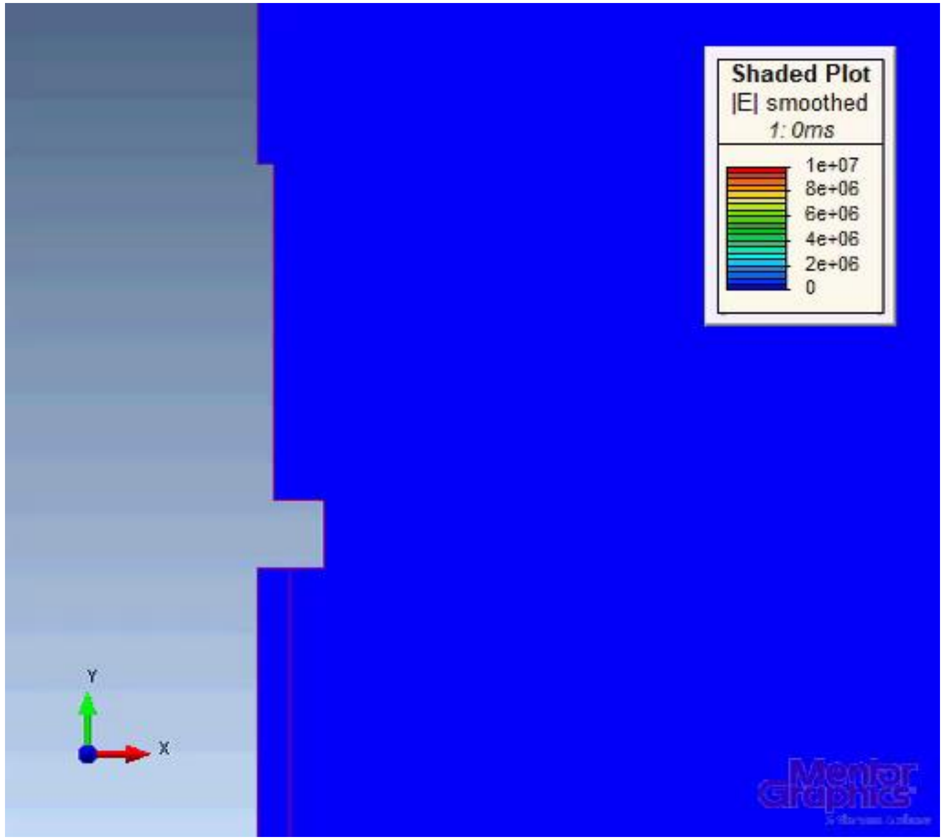
Typical thermal tests of surge arresters apply one or more voltage impulses followed by cool-down periods. In this study, as an example, a 330 kV impulse is applied to the top electrode of the model over 50 microseconds. This could represent a typical lightning strike. The voltage profile representing such an event is shown in this figure.

ELECTRIC FIELD DISTRIBUTION

The equipotential lines and the electric field magnitude distribution at the end of the impulse at 5.0E-5 seconds are shown here.



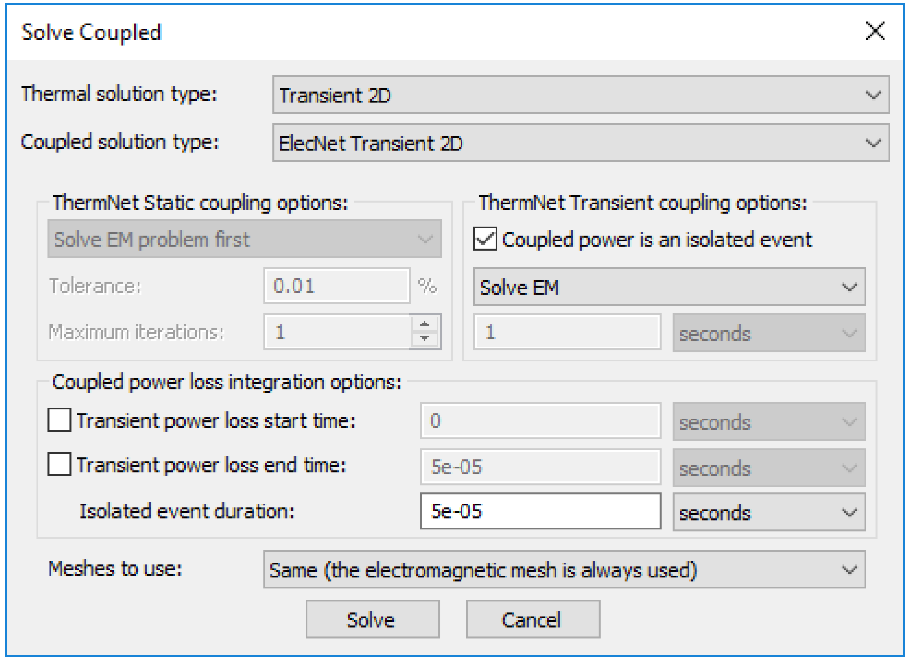
TRANSIENT FIELD DISTRIBUTION



The equipotential lines and the electric field magnitude distribution as a function of time are shown in this video.

COUPLING FOR THERMAL ANALYSIS

Assuming the process is adiabatic, the ElecNet/ThermNet coupling of the model is established to study the thermal characteristics of the device. The coupling is seamless and the solver interface between ElecNet and ThermNet is shown here. Adiabatic processes are defined as isolated events whose duration is specified at the interface. Also, a delay of 400 seconds is applied before the application of the lightning impulse. As such, in subsequent results, the temperature changes are tracked from 400 seconds onwards.



Solve Coupled

Thermal solution type: Transient 2D

Coupled solution type: ElecNet Transient 2D

ThermNet Static coupling options:

Solve EM problem first

Tolerance: 0.01 %

Maximum iterations: 1

ThermNet Transient coupling options:

☑ Coupled power is an isolated event

Solve EM

1 seconds

Coupled power loss integration options:

☐ Transient power loss start time: 0 seconds

☐ Transient power loss end time: 5e-05 seconds

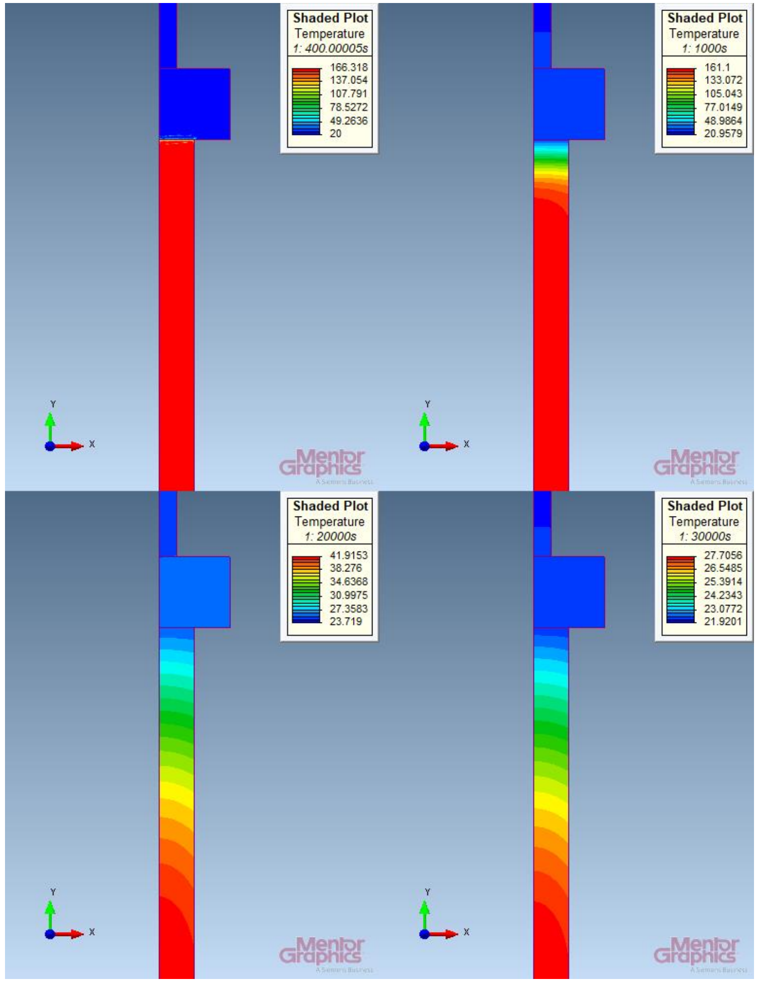
Isolated event duration: 5e-05 seconds

Meshes to use: Same (the electromagnetic mesh is always used)

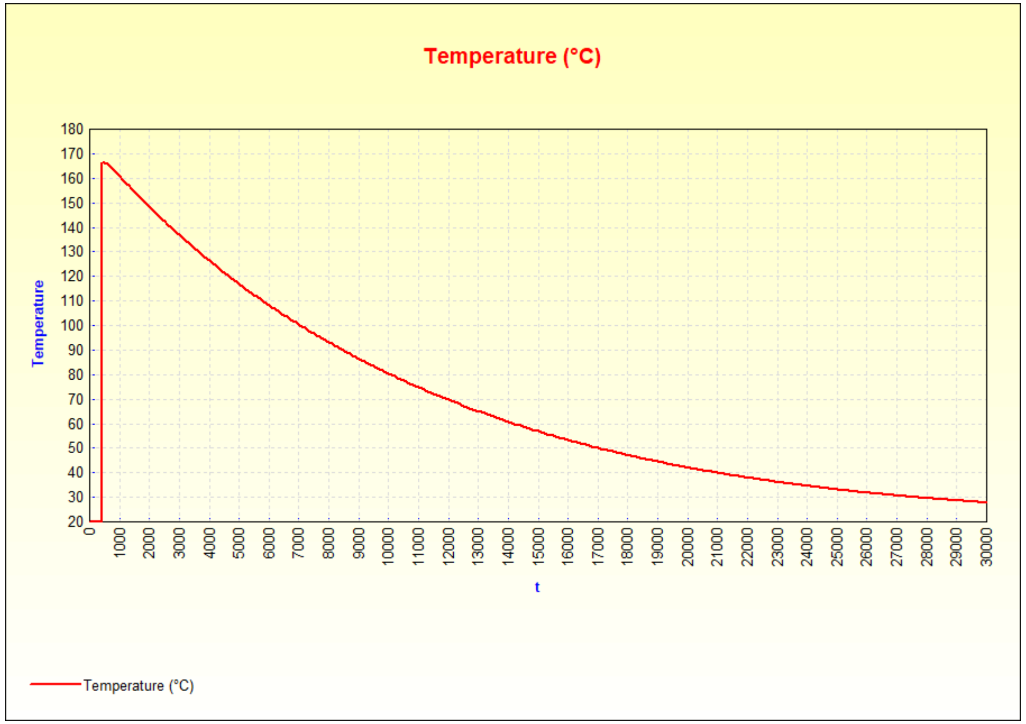
ELECTRIC-THERMAL SIMULATION RESULTS

Thermal processes including conduction, convection and radiation can be modeled in ThermNet. This is done by defining the thermal conductivity and specific heat capacity of the materials and by setting up boundary conditions on model surfaces. Note that in ThermNet a number of boundary conditions can be applied, such as fixed temperatures, heat sources, etc.

The key question for coupled electric-thermal analysis is to determine the maximum temperatures reached in various parts of the model as well as the post-event cooldown pattern. This figure shows the model temperatures at times 400, 1000, 20000 and 30000 seconds. The temperature distribution as well as the thermal time variations give the expected results.



TEMPERATURE VS. TIME



The results plotted here show the temperature variation in the middle of the resistor as a function of time. The expected cooling rates are verified by this plot.

SURGE ARRESTER TEMPERATURE DISTRIBUTION

An animation of the temperature distribution in the model as a function of time is shown here.