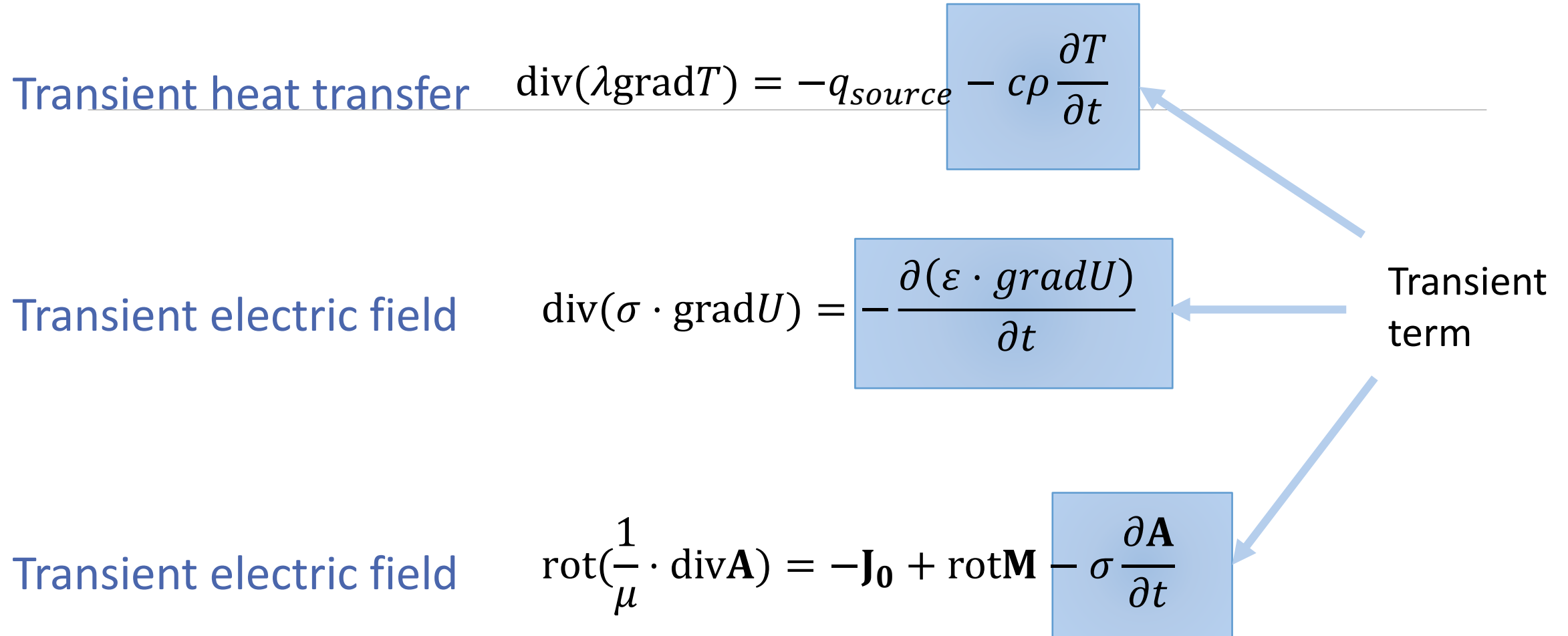


Transient analysis: everything= $f(\text{time})$

1. Equations with time-derivative term?
2. Time discretization
3. Choosing the correct time step.
4. Transient excitation
5. Transient postprocessing:
field pictures, local values, integral values
6. Effect of automatic time stepping

Governing Equation



Time Stepping

Time Integration:	From	To
Time range:	0	T _{MAX}
Time Step:	ΔT: fixed or automatic	
Storing results		
With time step:	n·ΔT	
Starting from:	0 or T _{MIN}	T _{MAX}

Editing time parameters

Problem Properties - TElec2.pbm

General Timing

Integration over Time

Calculate up to: 0.00001 (s)

With the step of: 1.e-7 (s)

☐ Calculate time steps automatically

Output

Store the results every: 1.e-7 (s)

Starting from the moment: 0 (s)

Initial temperature: (°C) **f**

OK Cancel Help

Time range (the upper bound)

Time step

Uniform initial value T_0
(only available for heat transfer analysis)

Automatic time step estimation

Choosing initial time-step

Starting from governing equation

$$\text{div}(\lambda \text{grad} T) = -q_{\text{source}} - c\rho \frac{\partial T}{\partial t}$$

Replace spatial and time derivatives with discrete analogues

$$\frac{\lambda \cdot \Delta T}{(\Delta l)^2} = c\rho \frac{\Delta T}{\Delta t} \Rightarrow \frac{(\Delta l)^2}{\Delta t} = \frac{\lambda}{c\rho}$$

Finally get the criterium of time-space coordination:

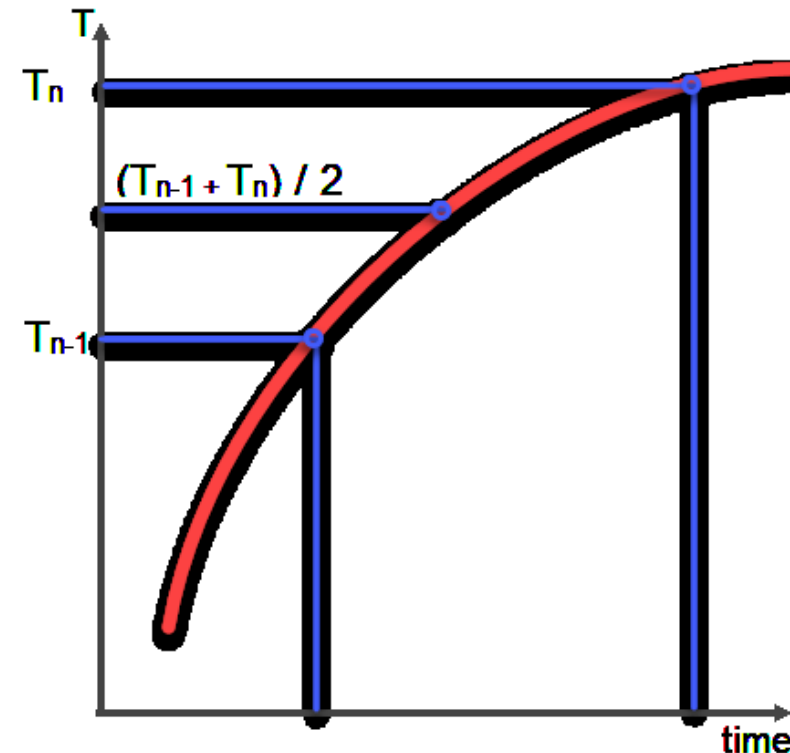
$$\Delta t = \min \left(\frac{(\Delta l)^2}{4\alpha} \right), \text{ where } \alpha = \frac{\lambda}{c\rho}$$

Time-step correction

The next time step is:

$$\Delta t_{n+1} = k \cdot \Delta t_n, \text{ where } k \in \left\{ \frac{1}{4}, \frac{1}{2}, 1, 2, 4 \right\}$$

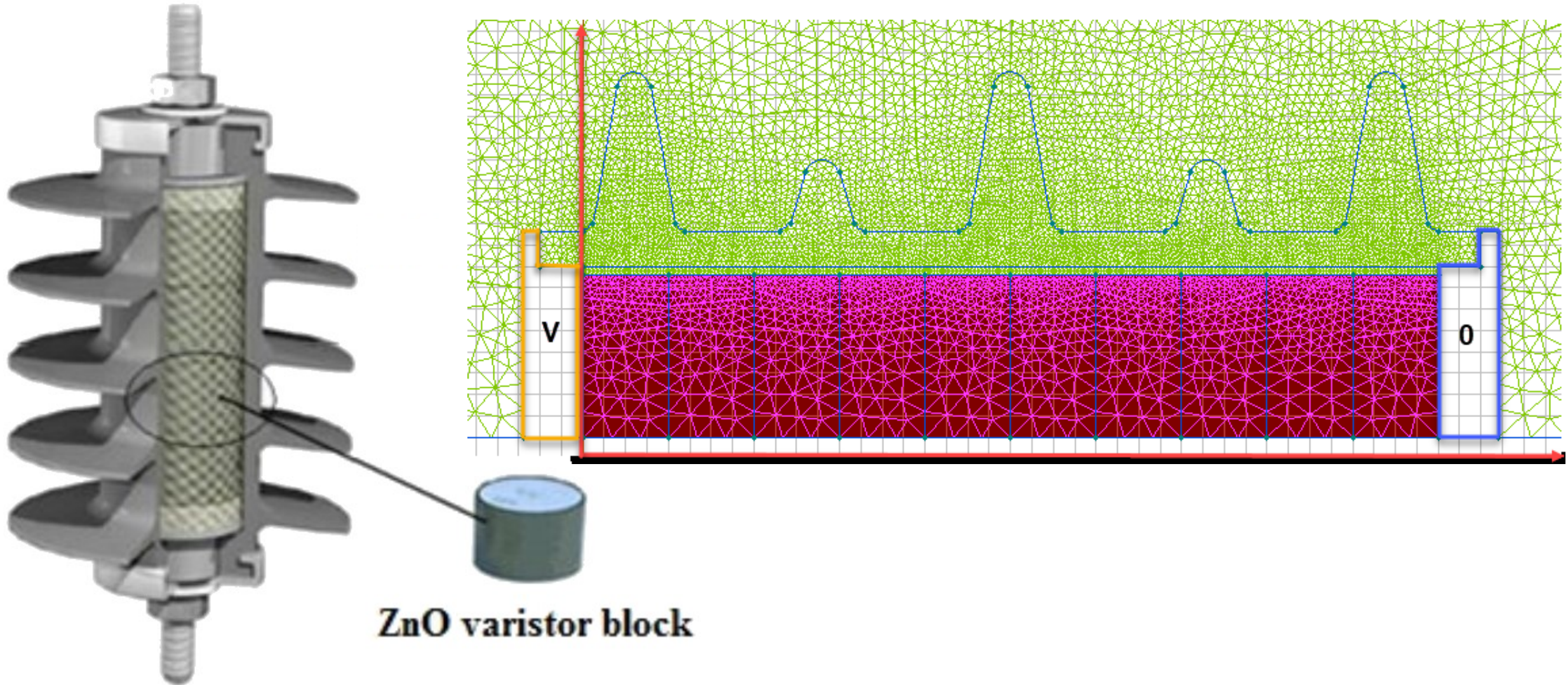
Dimensionless time derivative estimation:



$$2 \frac{u_n - u_{n-1}}{u_n + u_{n-1}}$$

next k is
 sen according to
 e derivative
 nation Δu

Example 1: Surge Arrester based on ZnO varistor



Voltage pulse applied to the arrester

Standard voltage pulse:
 $1.2/50 \mu\text{s}$

Edge Label Properties - high voltage

General

☒ Voltage: $U = U_0$

$U_0 = 2.14e5 * (\exp(t/2.5e-5) - \exp(t/1.2e-7))$ (V)

☐ Normal Current Density: $j_n = j$ ($\Delta j_n = j$)

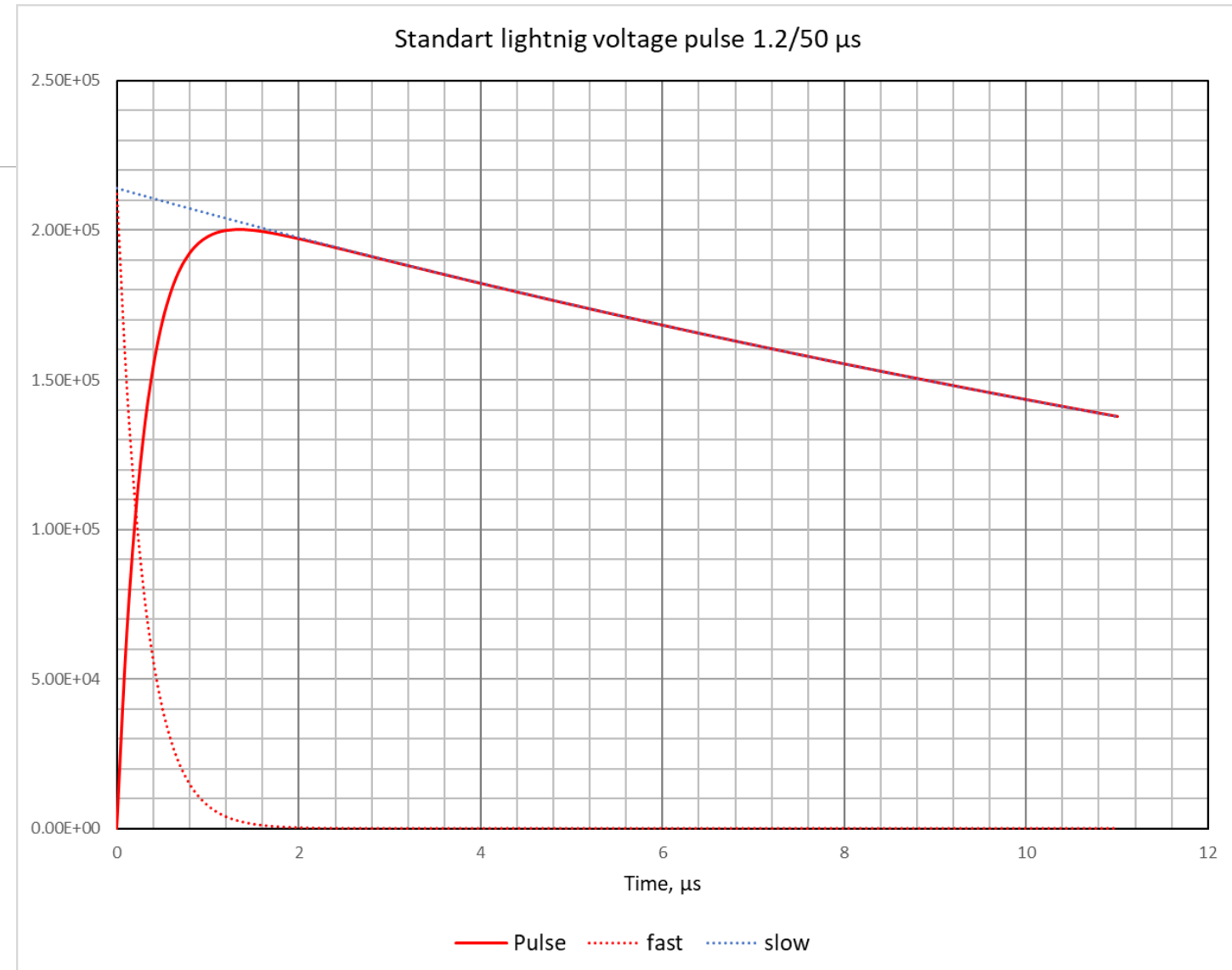
$j = 0$ (A/m²)

☐ Floating Conductor (Equal Voltage)

☐ Even Periodic: $U_1 = U_2$

☐ Odd Periodic: $U_1 = -U_2$

OK Cancel Help



Postprocessing in transient analysis

1. Field pictures and other analysis tools work as usual

within chosen time slice: $t = t_n$

2. Time plot and time tables available for both local and integral values

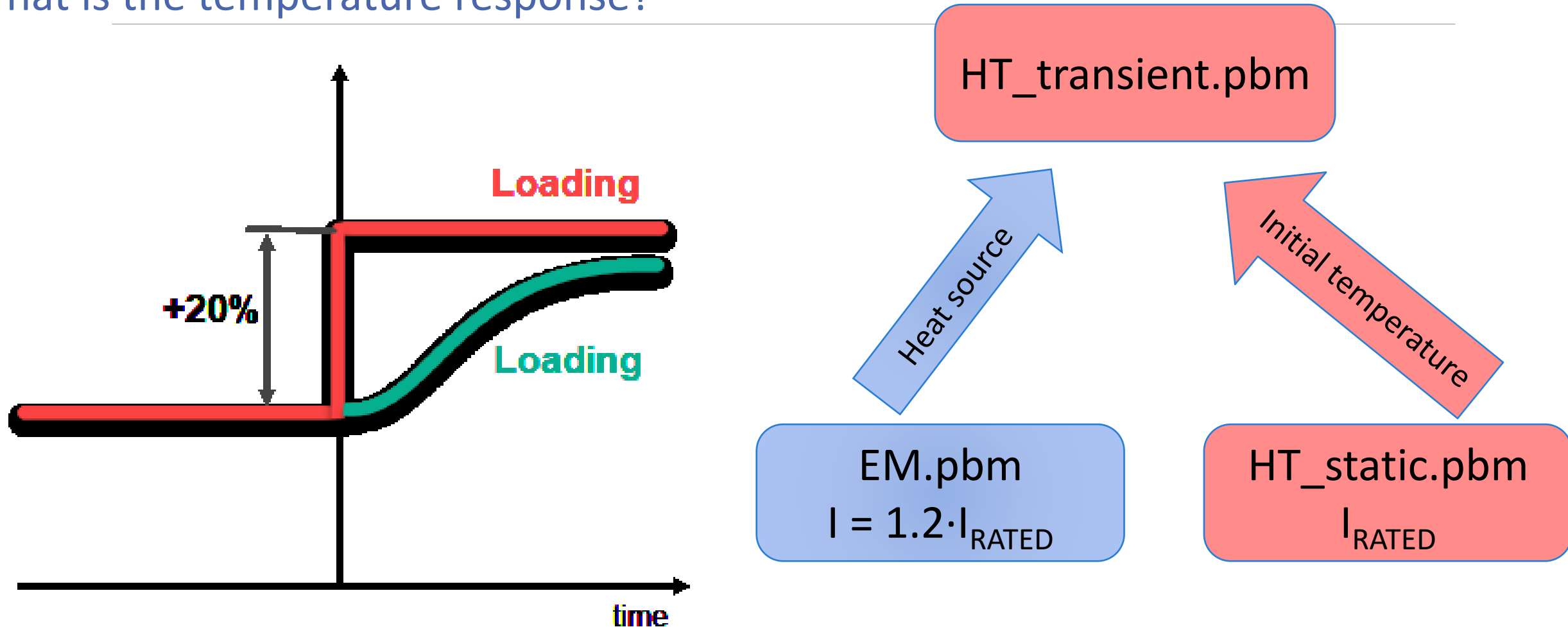
3. No integration over time so far, sorry!

Workaround: use third party tools (Excel,...)

4. Manual and automatic animation available

Example 2: Cable line overload

Let's assume that we are forced to increase line current by 20% after an accident.
What is the temperature response?



Problem coupling and transient data

Two linked problem

Problem Properties - trefoil_one_overload_HT.pbm

General Links Timing

Data Imported from Other Problem

Data Sources:

Generated heat: Trefoil_one_overload.pbm	Delete
Temperature field: Trefoil_one_ht.pbm	Delete

Delete All

Data Link

Data Type: Temperature field Update

Problem: Trefoil_one_ht.pbm Browse...

Time:

Options:

OK Cancel Help

Specific heat; Mass density

Block Label Properties - soil

General

Thermal Conductivity

$\lambda_x = 1$ (W/K.m)

$\lambda_y = 1$ (W/K.m)

☐ Nonlinear ☐ Anisotropic

Volume Power of the Heat Source

Q = 0 (W/m³) **f**

☐ Depends on Temperature

For Time-Domain Only

C = 840 (J/kg.K)

☐ Nonlinear

$\rho = 1600$ (kg/m³)

Coordinates

☒ Cartesian ☐ Polar

OK Cancel Help

Effect of automatic time stepping

Integration over Time

Calculate up to: (s)

With the step of: (s)

☒ Calculate time steps automatically

Automatic time step
effective with long
transient process

