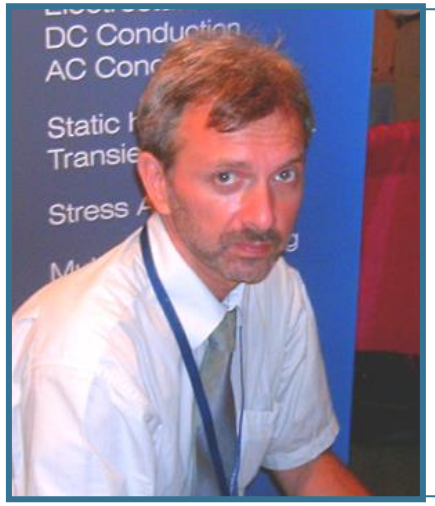
Joule heating calculation with QuickField



Vladimir Podnos

Director of Marketing and Support
Tera Analysis Ltd.

Alexander Lyubimtsev

Support Engineer
Tera Analysis Ltd.

https://quickfield.com/seminar/seminar_joule_heating.htm

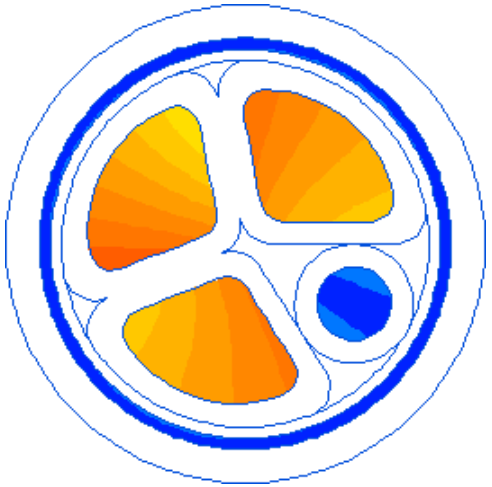
QuickField Analysis Options

Magnetic analysis suite	Magnetostatics
	AC Magnetics
	Transient Magnetic
Electric analysis suite	Electrostatics (2D,3D) and DC Conduction (2D,3D)
	AC Conduction
	Transient Electric field
Thermostructural analysis suite	Steady-State Heat transfer (2D,3D)
	Transient Heat transfer
	Stress analysis

https://quickfield.com/pack.htm

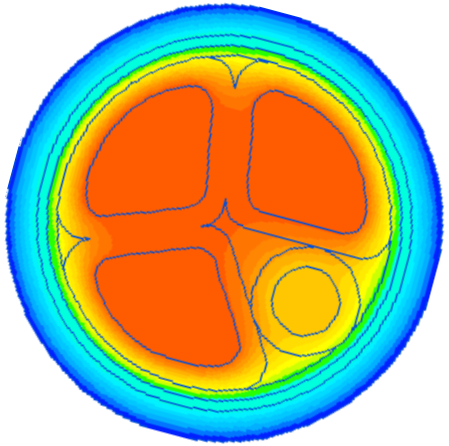
MultiPhysics (2D)

Electromagnetic fields



Losses

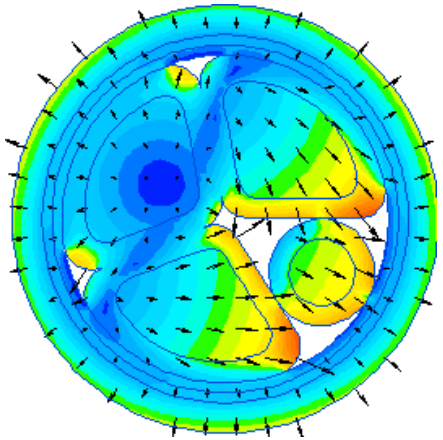
Temperature field



Temperature field import

Magnetic state import

Forces



Thermal Stresses

Stresses & Deformations

https://quickfield.com/coupling.htm

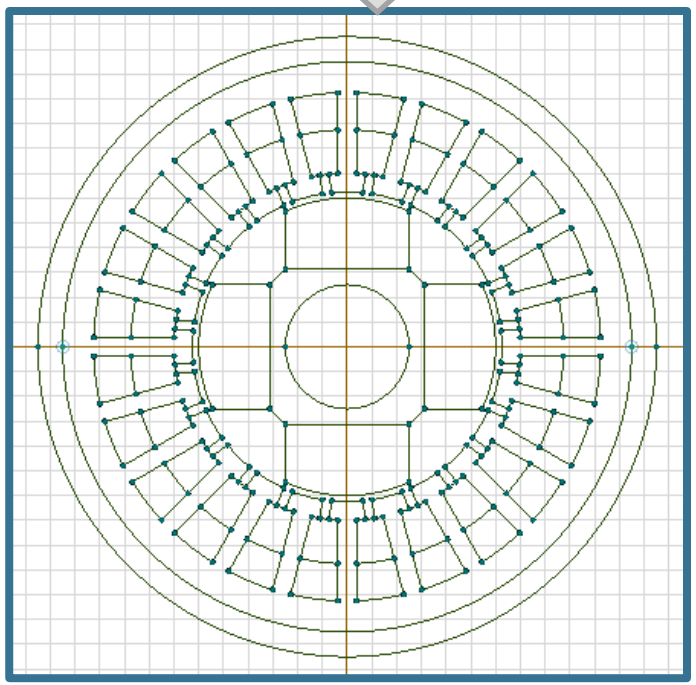
MultiPhysics (2D)

	Destination problem					
Source problem	DC magnetics	AC magnetics	Transient magnetics	Static heat transfer	Transient heat transfer	Stress Analysis
DC magnetics	Magnetic permeability	Magnetic permeability	Initial magnetic field			Force
AC magnetics				**Joule heat**	**Joule heat**	Force
Transient magnetics			Initial magnetic field	**Joule heat**	**Joule heat**	Force
Electrostatics						Force
DC conduction				**Joule heat**	**Joule heat**	
AC conduction				**Joule heat**	**Joule heat**	Force
Static heat transfer		Temperatures			Initial temperatures	Temperatures
Transient heat transfer		Temperatures			Initial temperatures	Temperatures

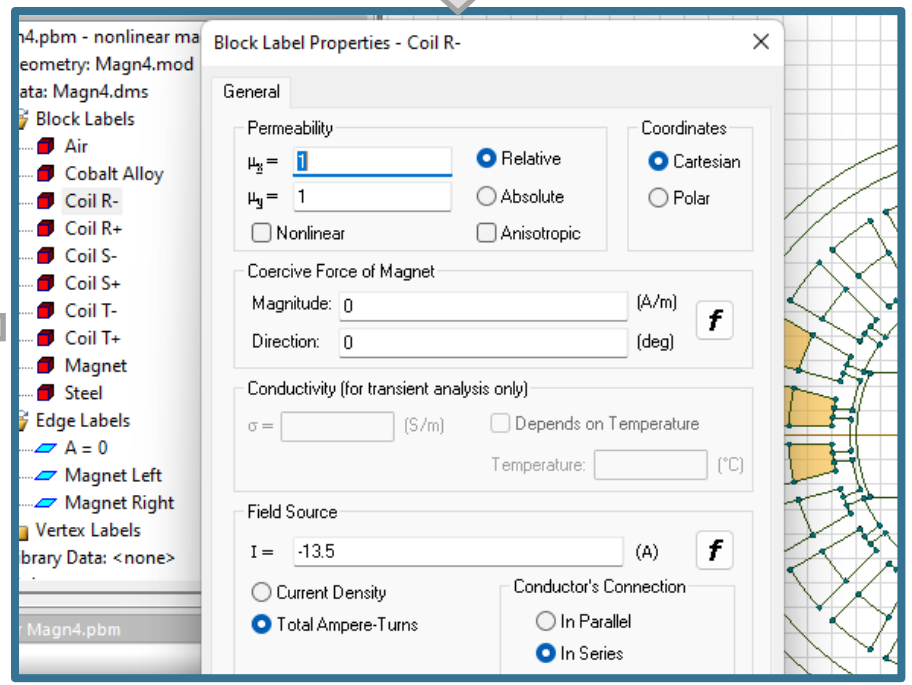
https://quickfield.com/coupling.htm

QuickField Workflow

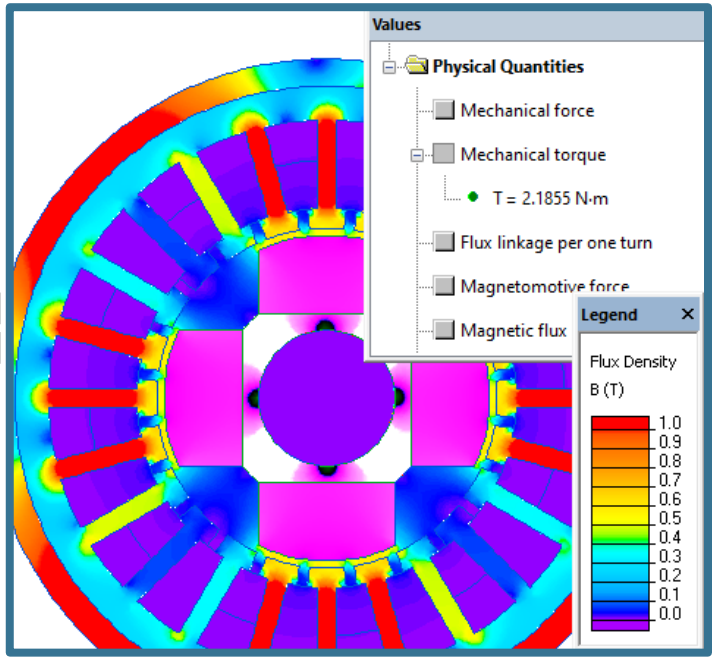
Problem setup



Model editor



Material physical properties, field sources and boundary conditions



Results analysis

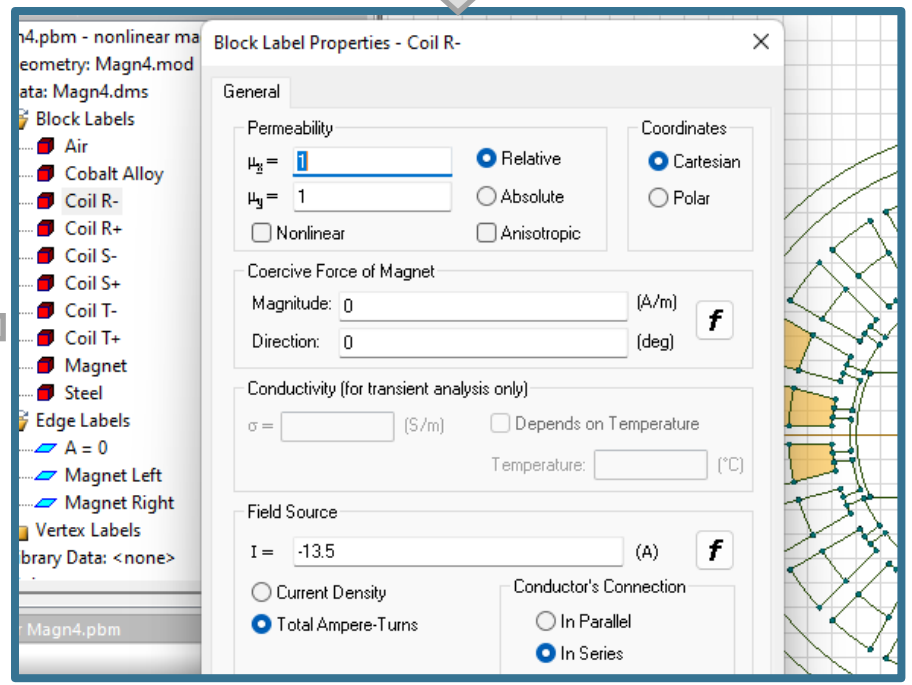
QuickField Workflow

Destination Problem setup

Source problem

Reference to the geometrical model previously used in the source problem

+



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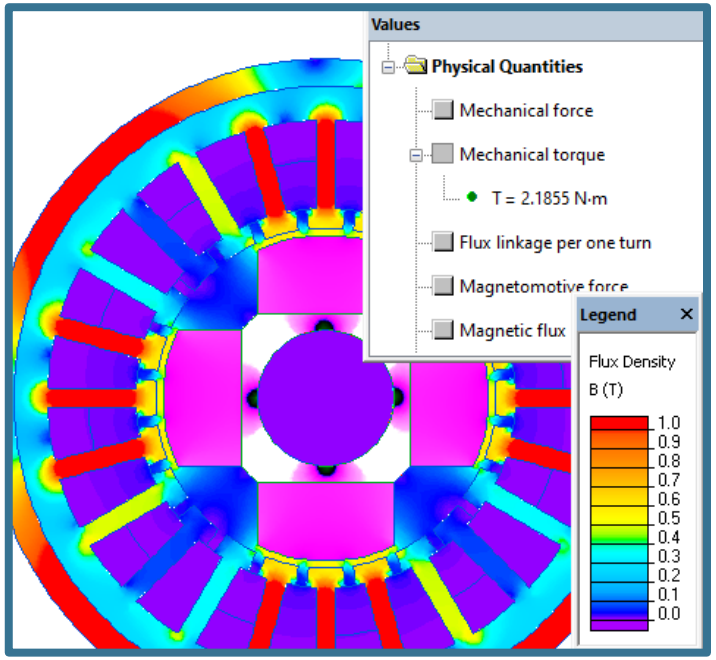
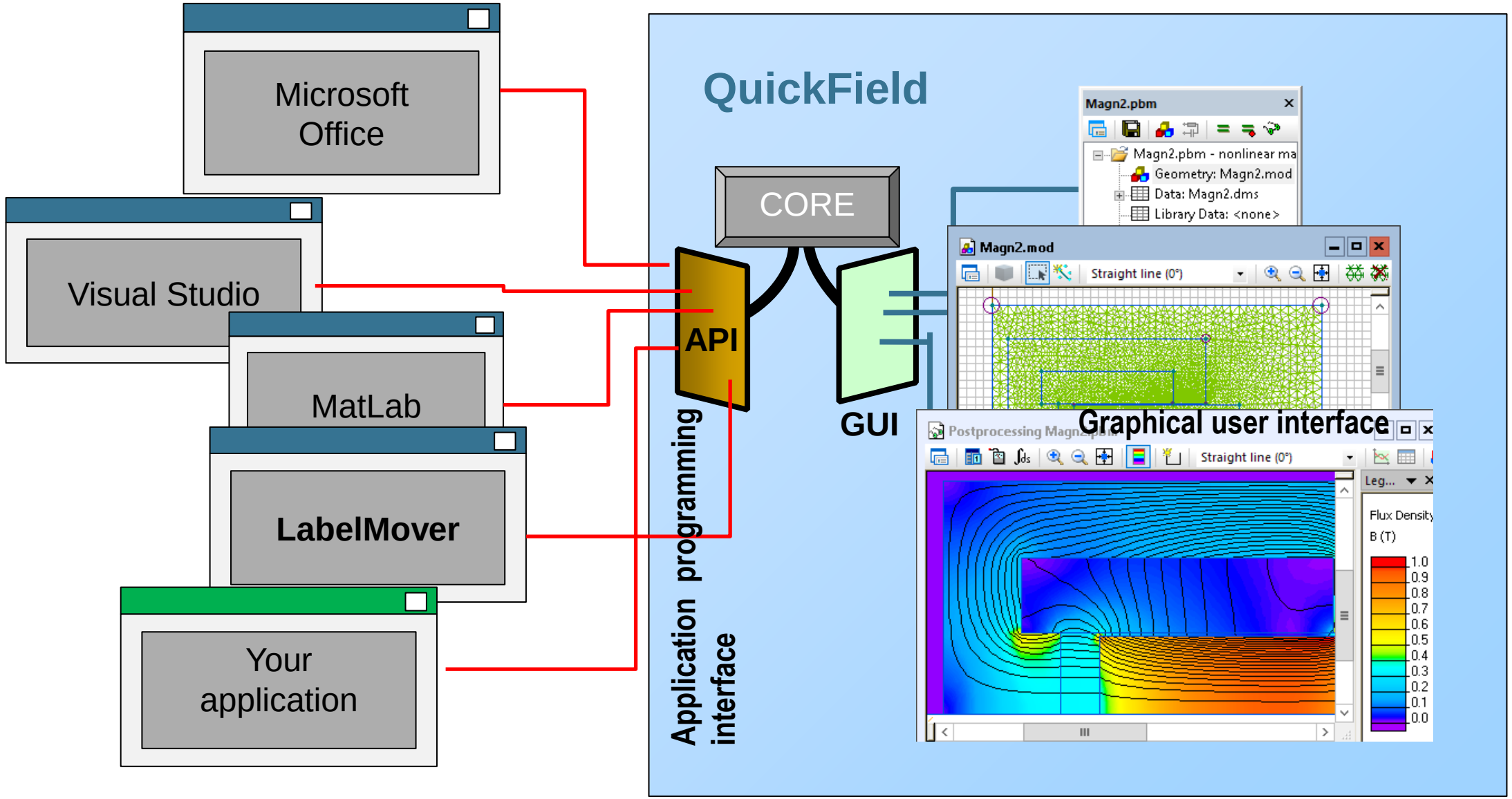


Material physical properties, field sources and boundary conditions

Results analysis

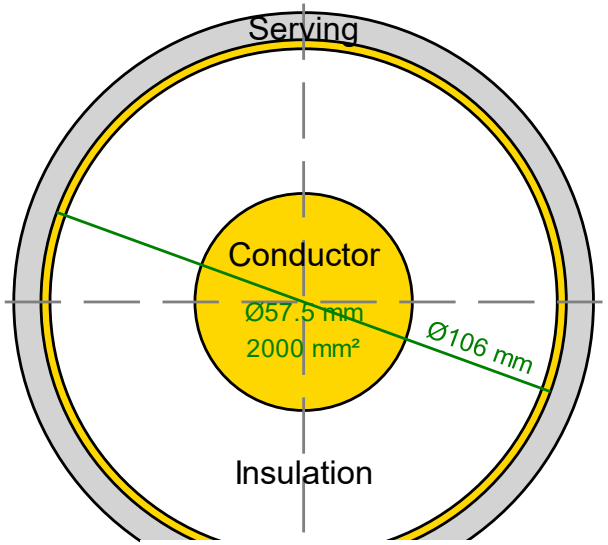
QuickField API

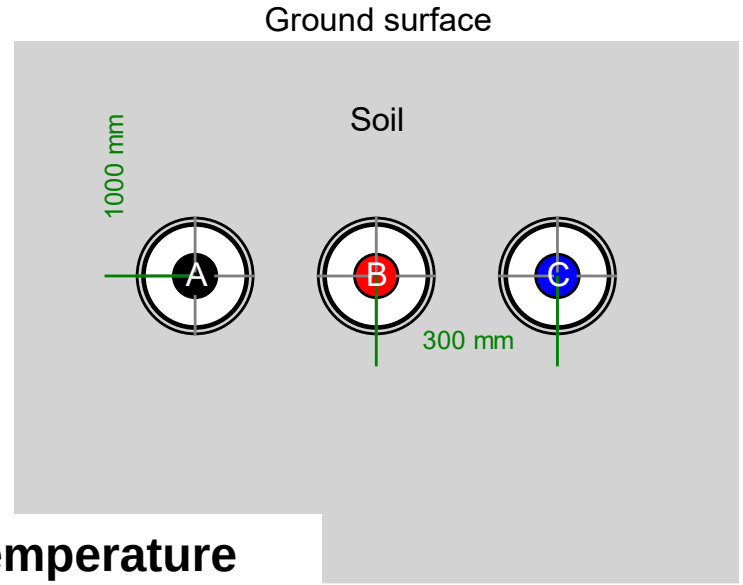


https://quickfield.com/programming.htm

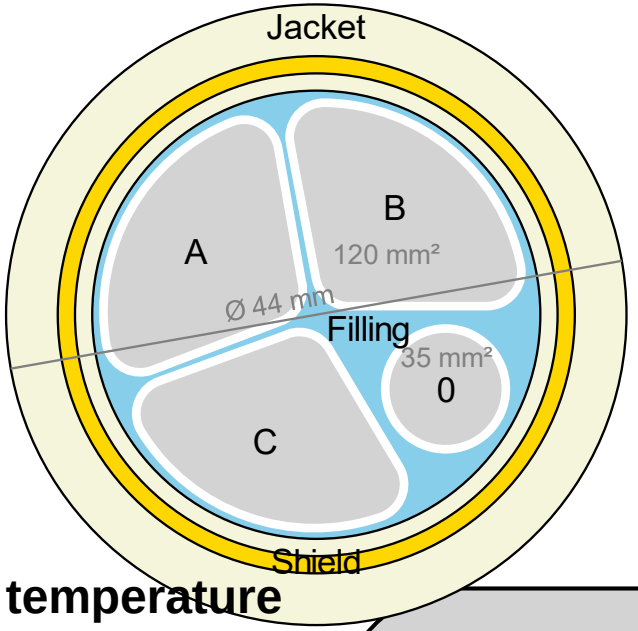
QuickField Difference

Joule heating calculation with QuickField

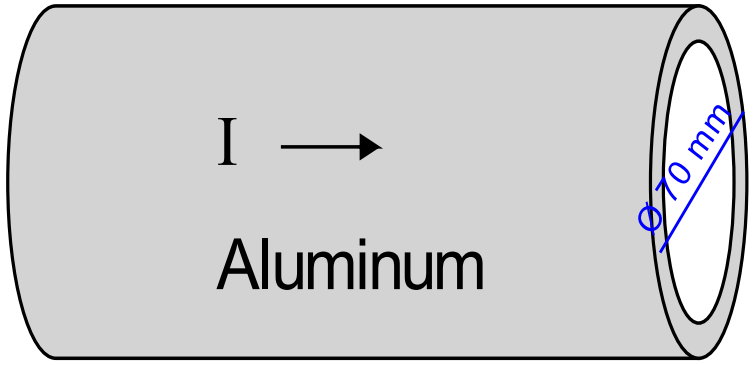




Underground cable temperature

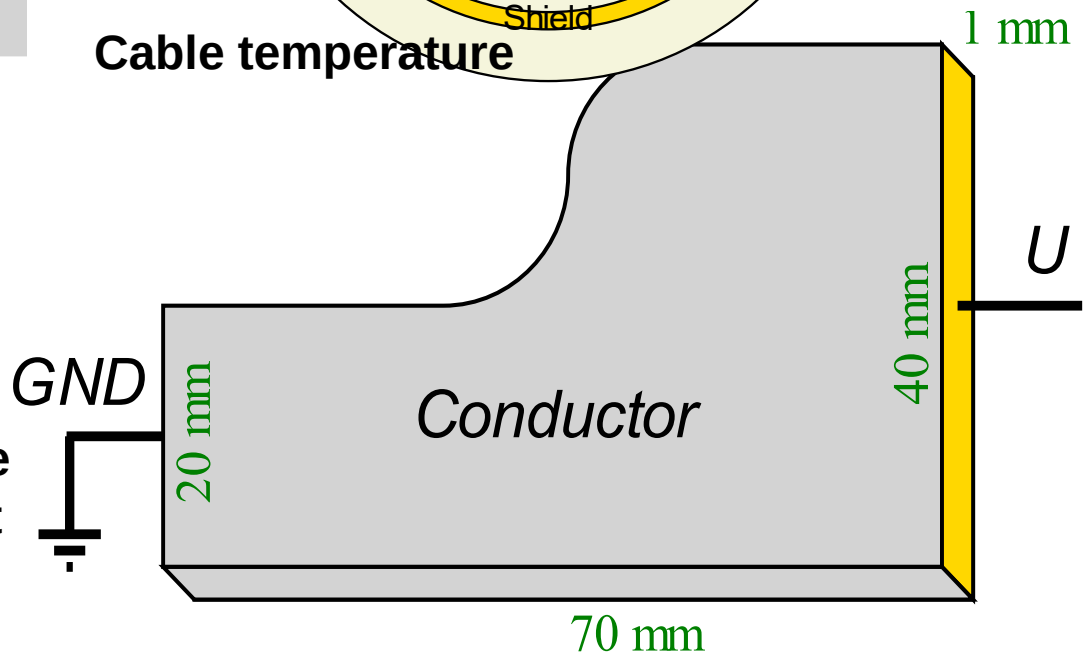


Cable temperature



Temperature dependent electrical resistance

Temperature distribution in the conducting sheet

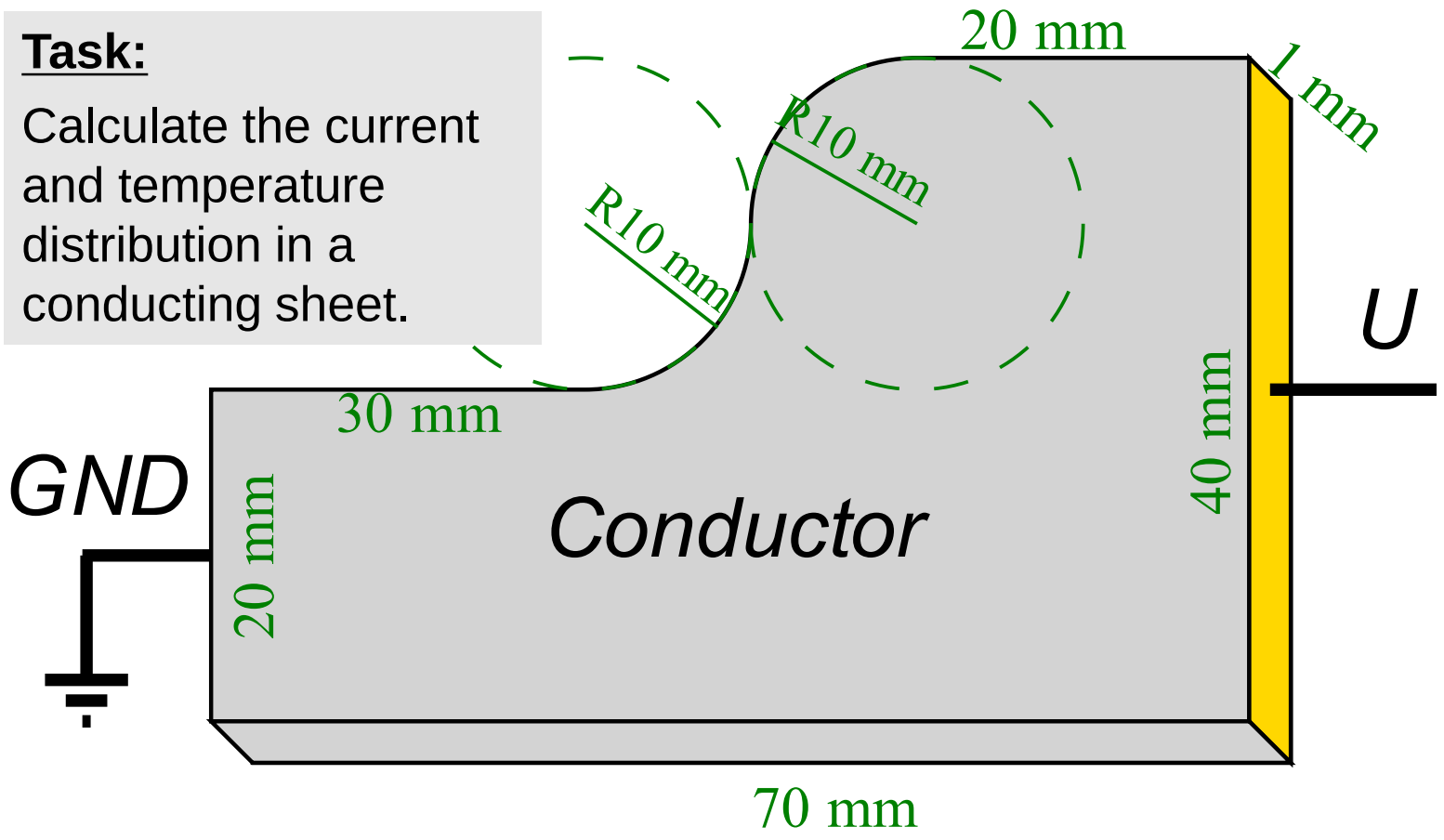


https://quickfield.com/seminar/seminar_joule_heating.htm

Temperature distribution in the conducting sheet

Task:

Calculate the current and temperature distribution in a conducting sheet.



Problem specification:

Voltage applied U = 0.02 V;

Electrical conductivity 1 MS/m;
Thermal conductivity 50 W/K-m.

Convection coefficient 10 W/K-m²;
Ambient air temperature 0°C.

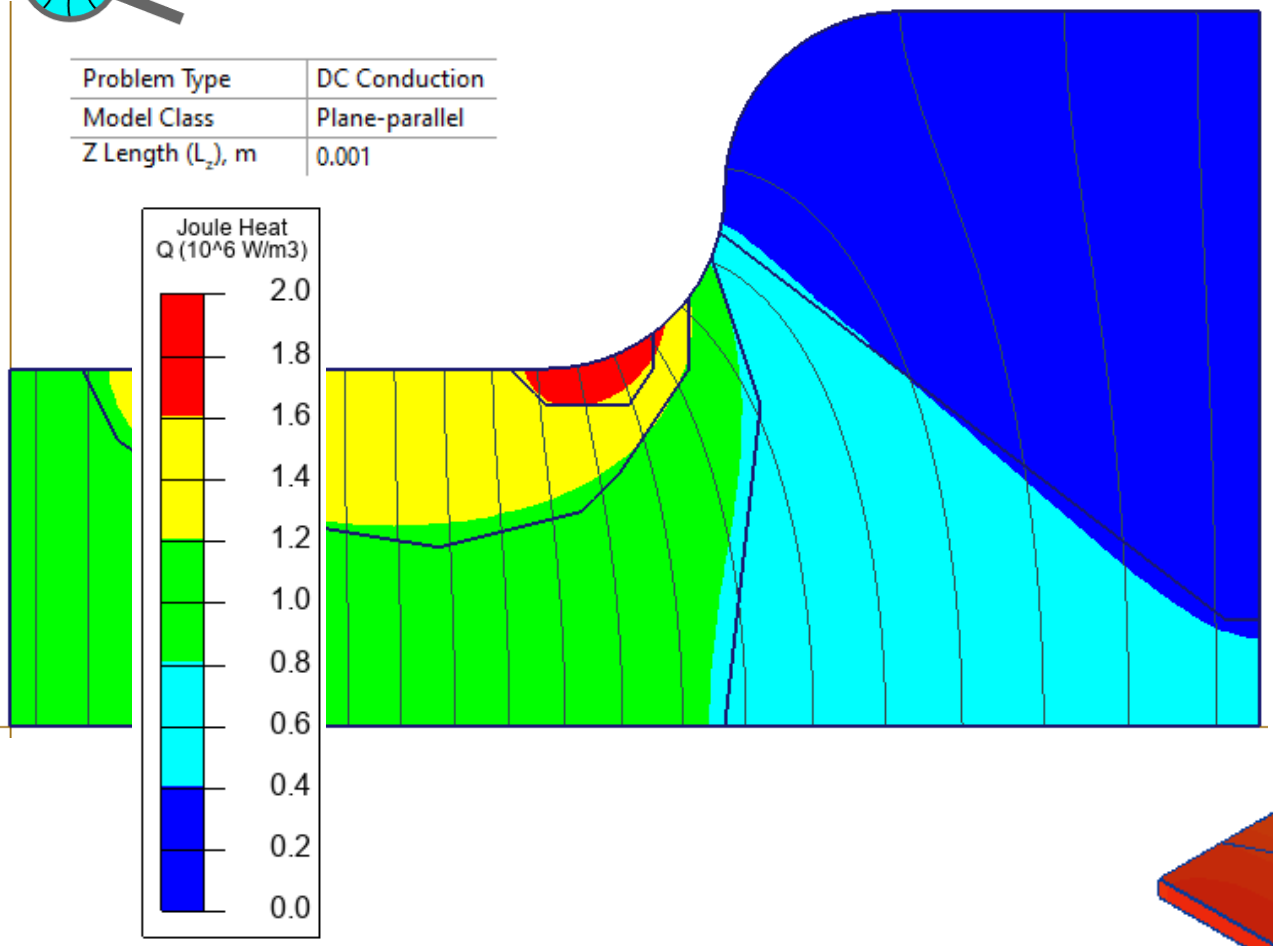
Joule heat power distribution

DC Conduction > 3D Steady-state Heat transfer

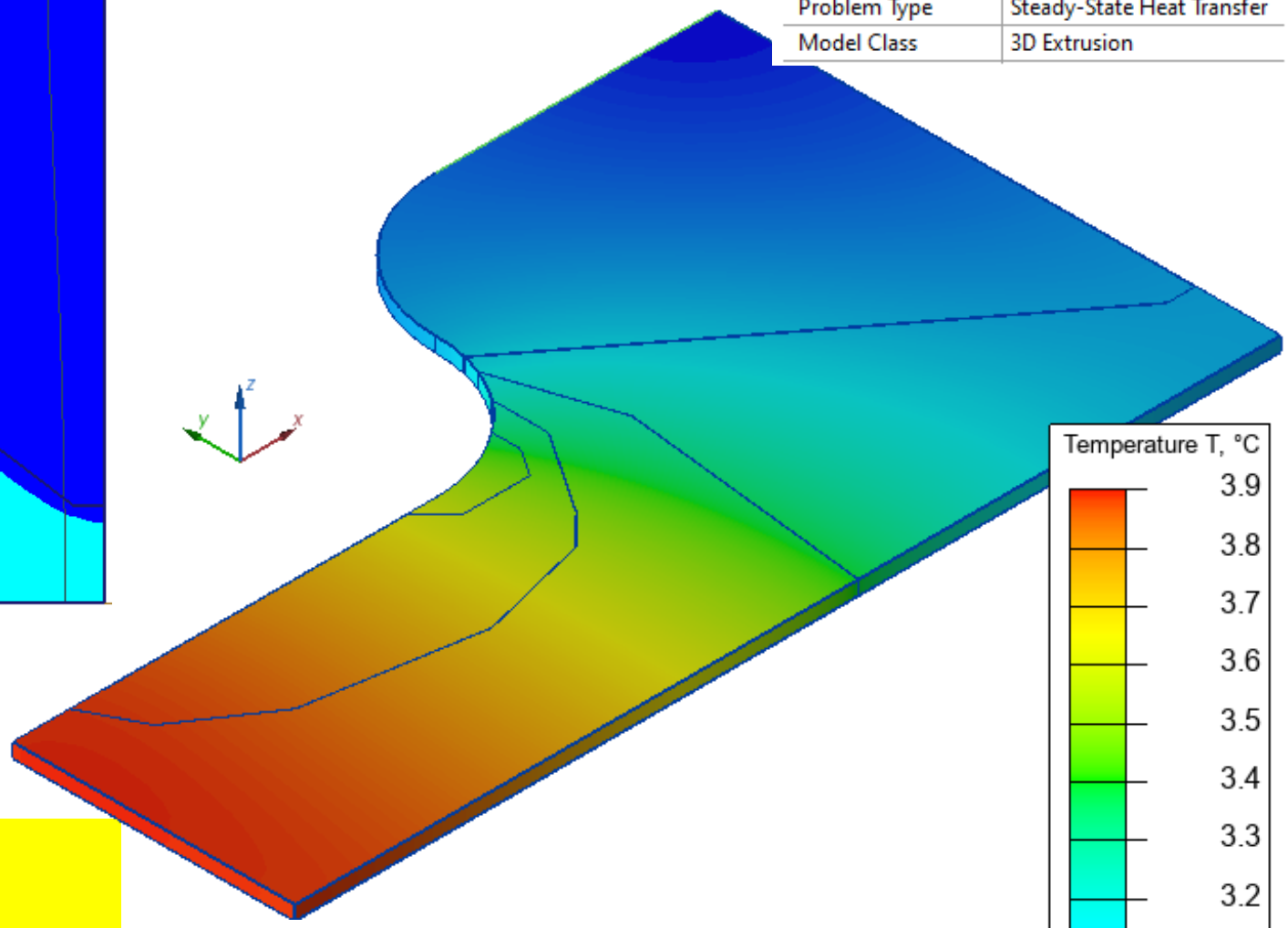
https://quickfield.com/advanced/conducting_sheet_temperature.htm

Temperature distribution in the conducting sheet

Problem Type	DC Conduction
Model Class	Plane-parallel
Z Length (L_z), m	0.001



Problem Type	Steady-State Heat Transfer
Model Class	3D Extrusion

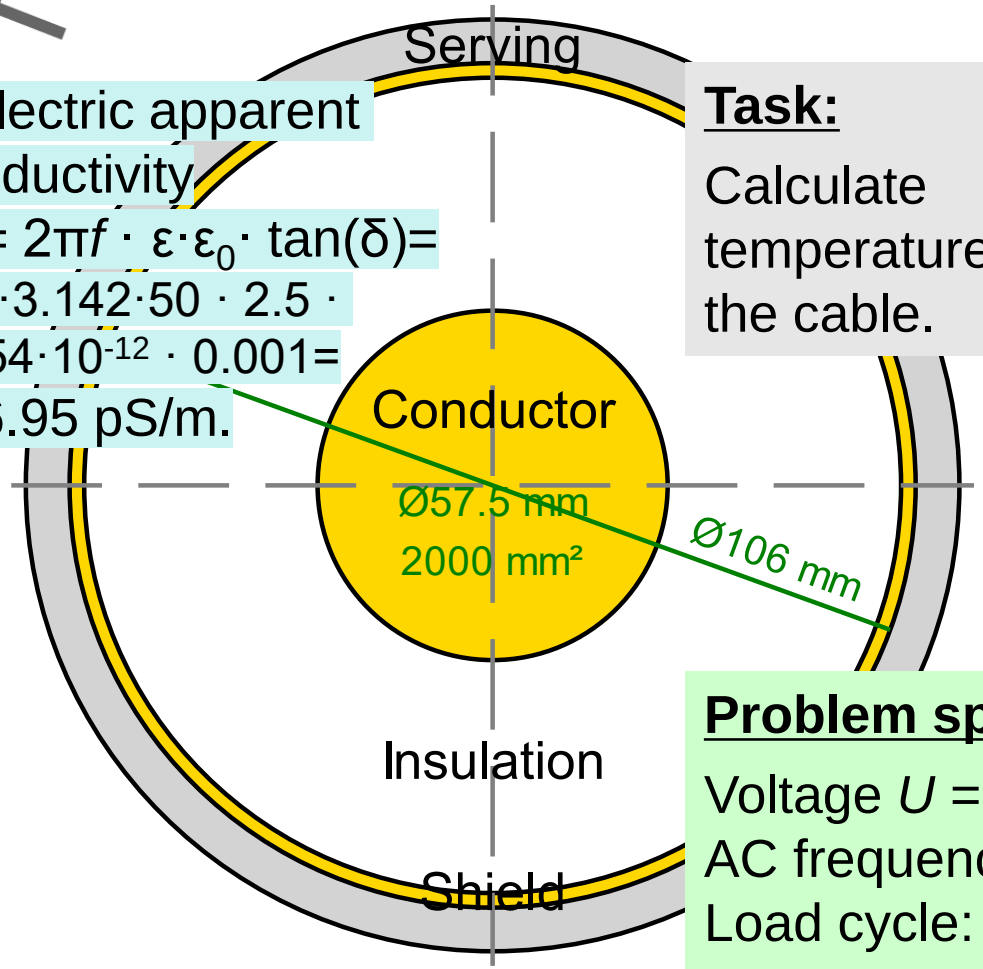


Joule heat power distribution

DC Conduction > 3D Steady-state heat transfer

https://quickfield.com/advanced/conducting_sheet_temperature.htm

Underground cable temperature



Dielectric apparent conductivity

$\sigma = 2\pi f \cdot \varepsilon \cdot \varepsilon_0 \cdot \tan(\delta) =$

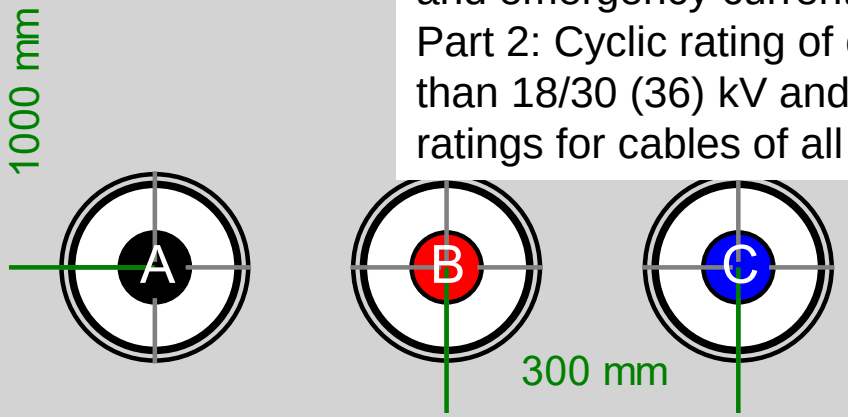
$= 2 \cdot 3.142 \cdot 50 \cdot 2.5 \cdot 8.854 \cdot 10^{-12} \cdot 0.001 =$

$= 6.95$ pS/m.

Task:

Calculate temperature of the cable.

Ground surface



IEC 60853-2. Calculation of the cyclic and emergency current rating of cables. Part 2: Cyclic rating of cables greater than 18/30 (36) kV and emergency ratings for cables of all voltages

Problem specification:

Voltage *U* = 400 kV (r.m.s.),
AC frequency is 50 Hz.
Load cycle: 0 A for many days.

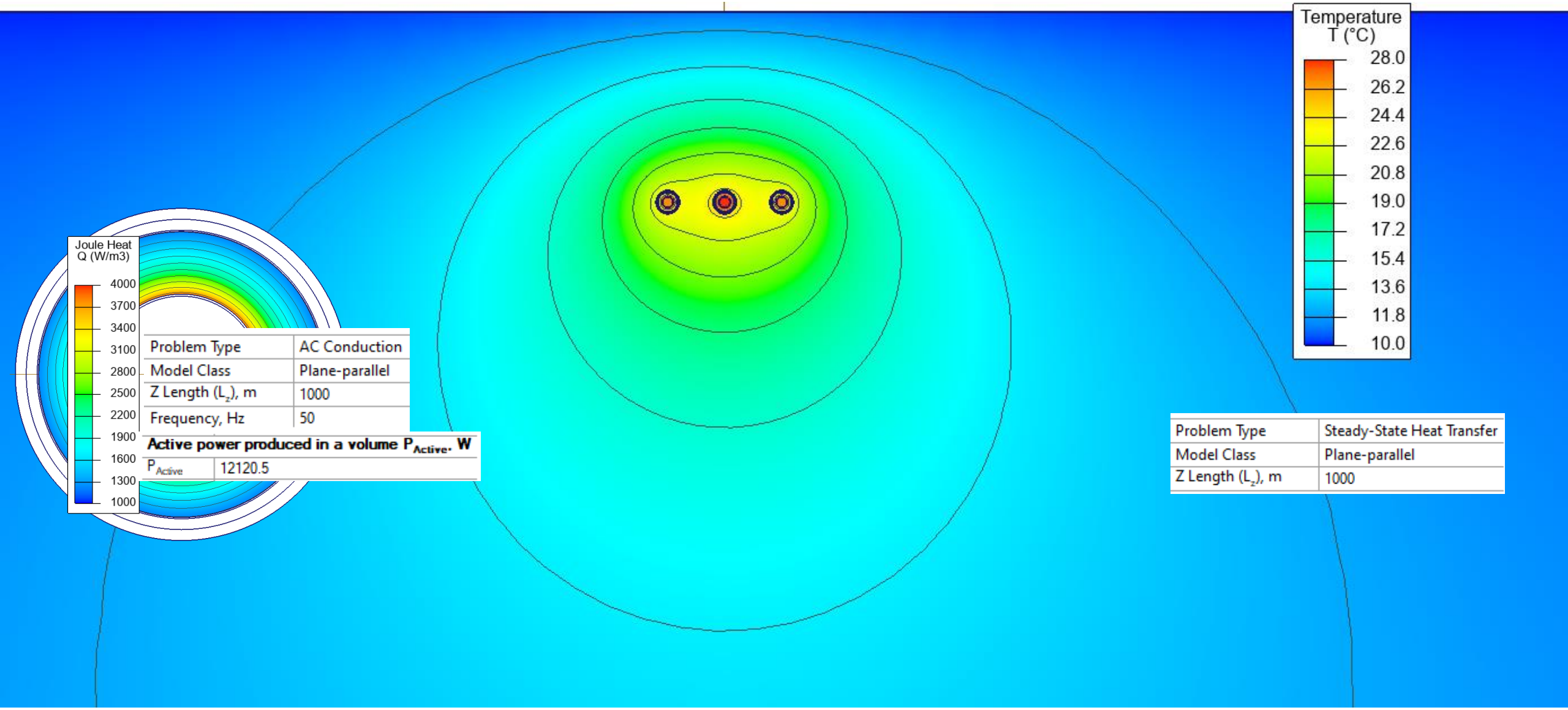
Insulation permittivity 2.5,
loss tangent tan(δ) = 0.001

Joule heat power distribution

AC Conduction > Steady-state heat transfer

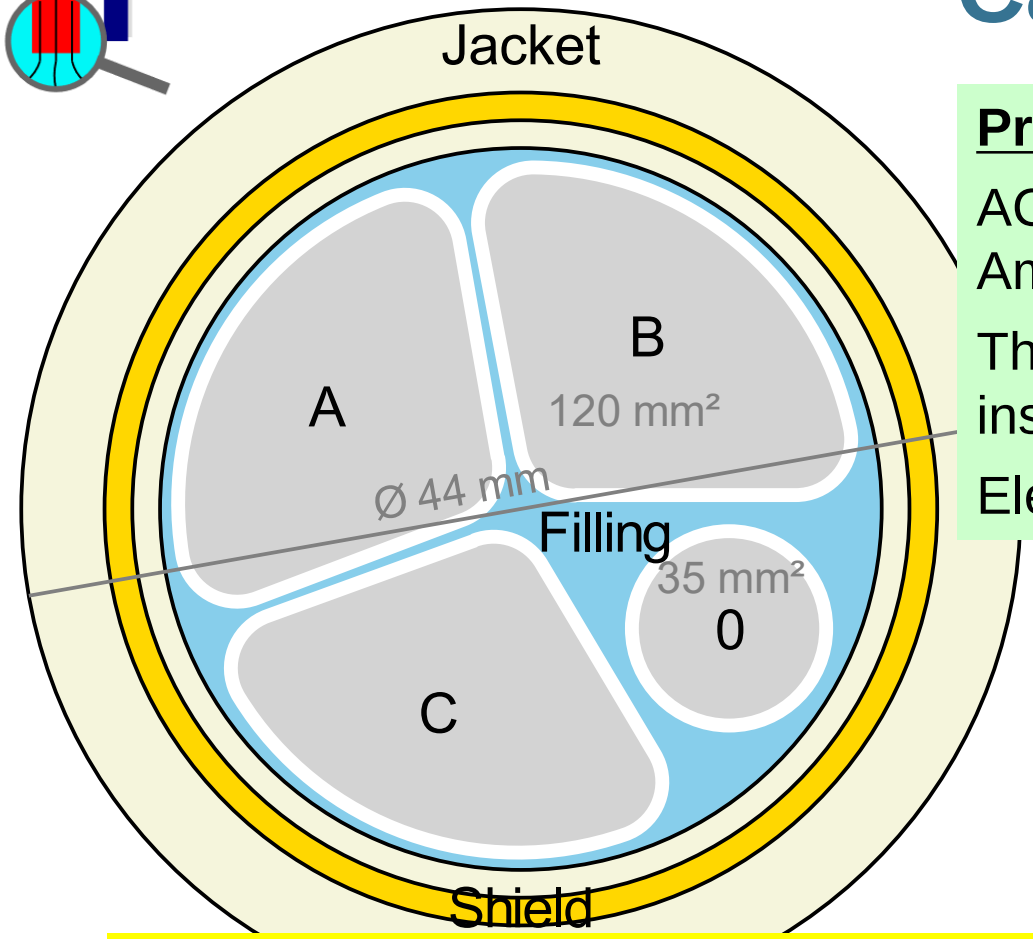
https://quickfield.com/advanced/cable_transients.htm

Underground cable temperature



https://quickfield.com/advanced/cable_transients.htm

Cable temperature



Problem specification:

AC current *I* = 150 A (r.m.s.), frequency 60 Hz.
Ambient air temperature +20°C, convection coefficient 5 W/m²K.

Thermal conductivity: aluminum 237 W/K-m, shield 380 W/K-m, insulation 0.2 W/K-m, jacket 0.29 W/K-m, filling 0.05 W/K-m

Electrical conductivity of metals depends on temperature.

Task:

Calculate the Joule heat loss and the temperature

Joule heat power distribution

AC Magnetics > Steady-state heat transfer

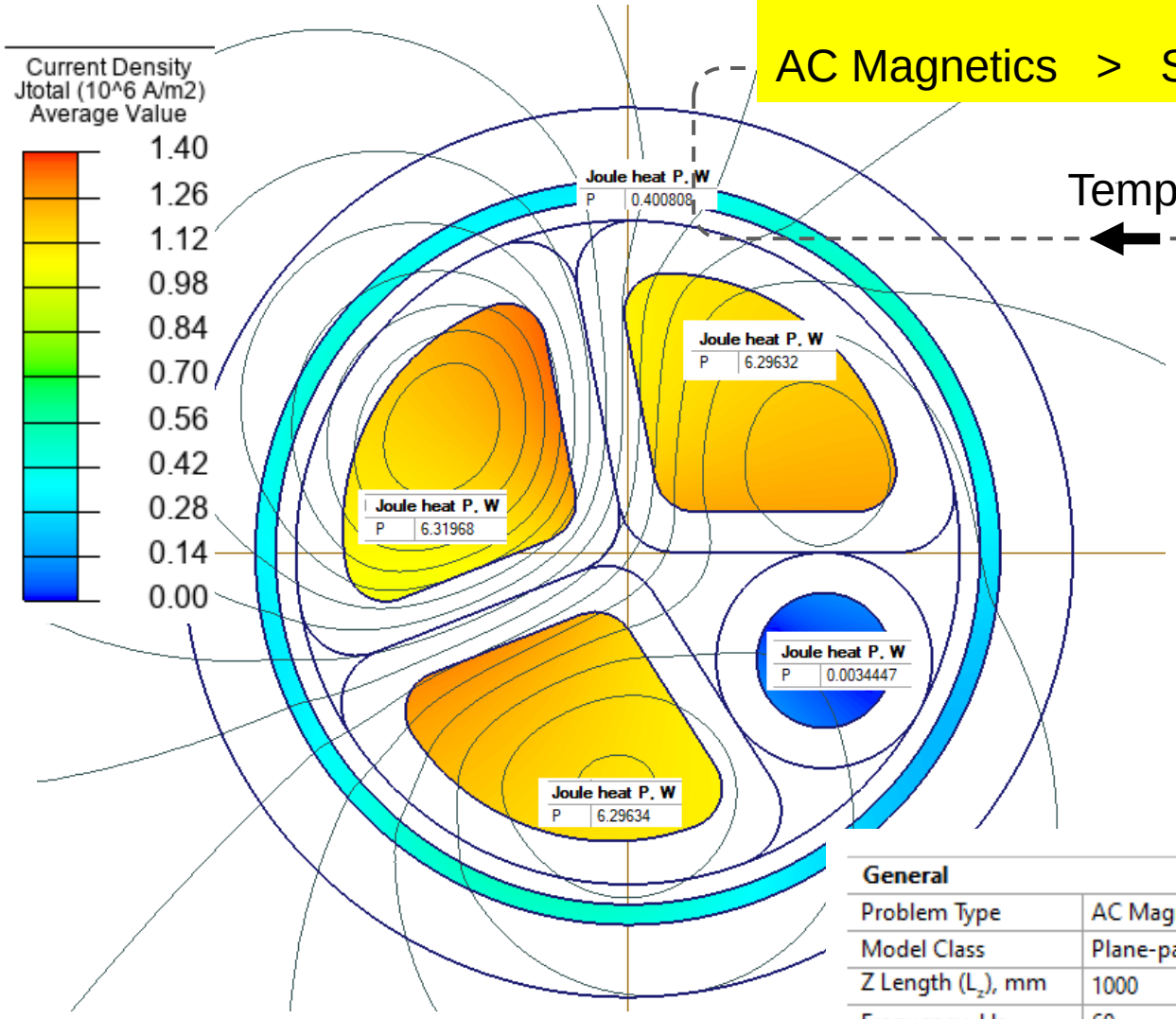
Temperature

https://quickfield.com/advanced/cable_temperature.htm

Cable temperature

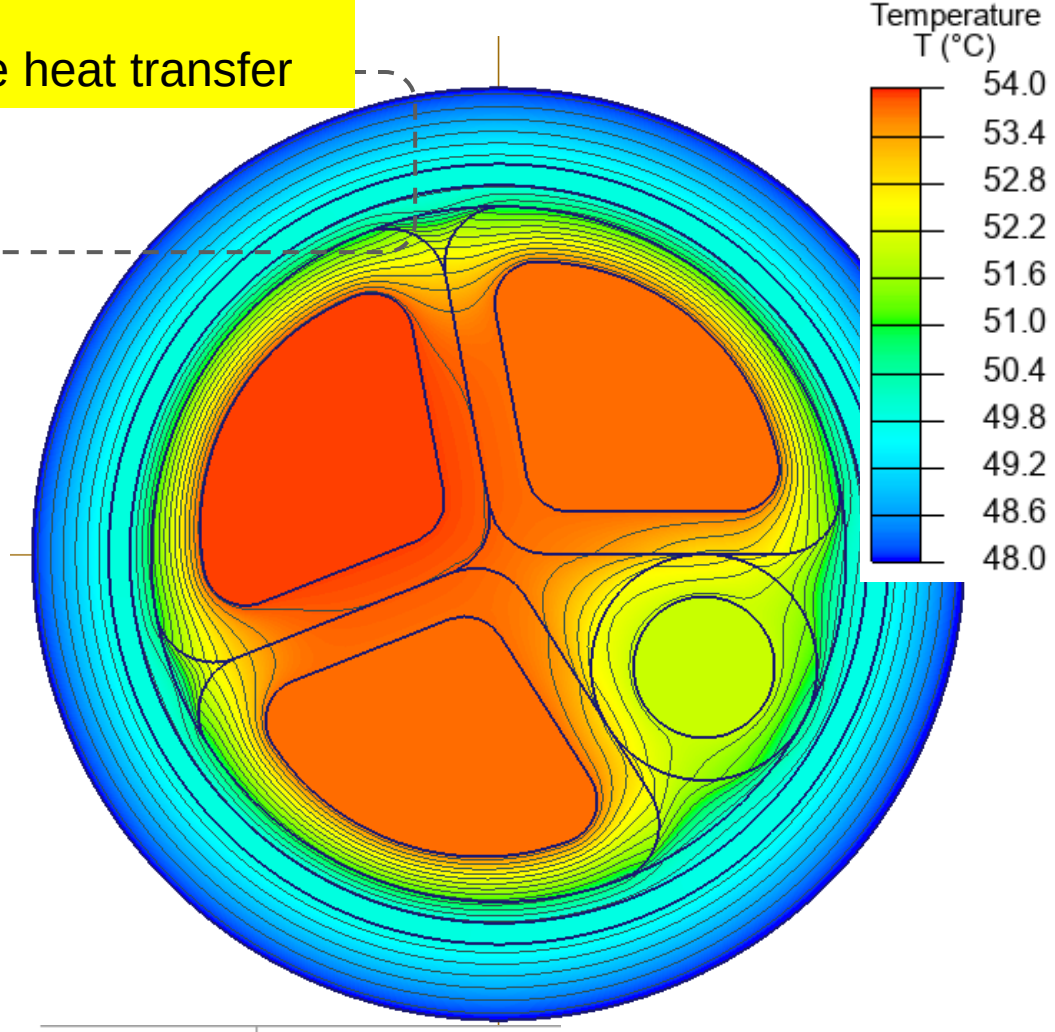
Joule heat power distribution

AC Magnetics > Steady-state heat transfer



General	
Problem Type	AC Magnetics
Model Class	Plane-parallel
Z Length (L_z), mm	1000
Frequency, Hz	60

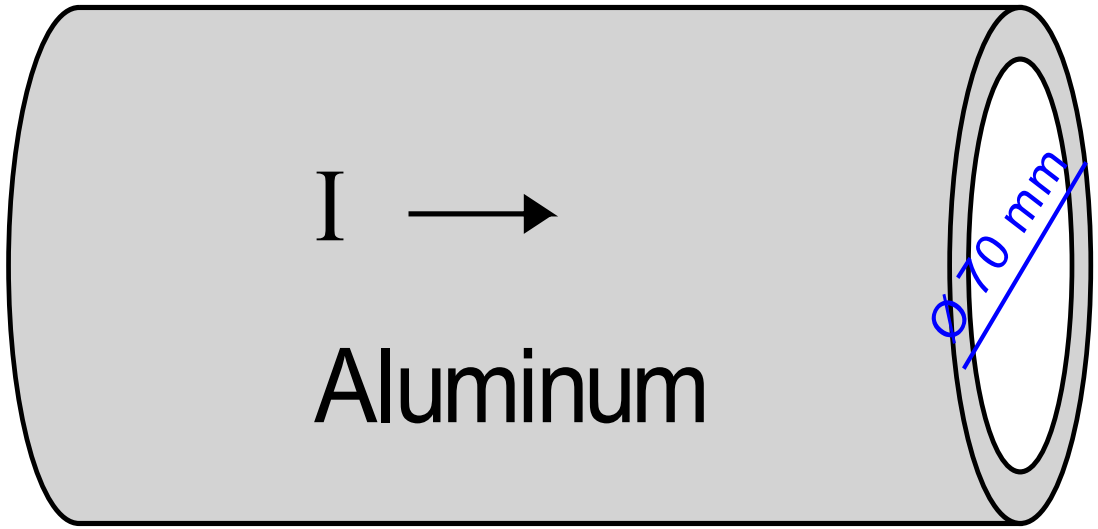
Temperature



Problem Type	Steady-State Heat Transfer
Model Class	Plane-parallel
Z Length (L_z), mm	1000

https://quickfield.com/advanced/cable_temperature.htm

Temperature dependent electrical resistance



Problem specification:

Resistivity of aluminum $\rho_{20°}$ = 2.65e-8 Ohm*m,
temperature coefficient of resistivity α = 0.00429 1/°C.
Current I = 1 kA;

Convection coefficient 5 W/K-m²,
ambient air temperature +20°C.

Task:

Calculate the conductor temperature.

Joule heat power distribution

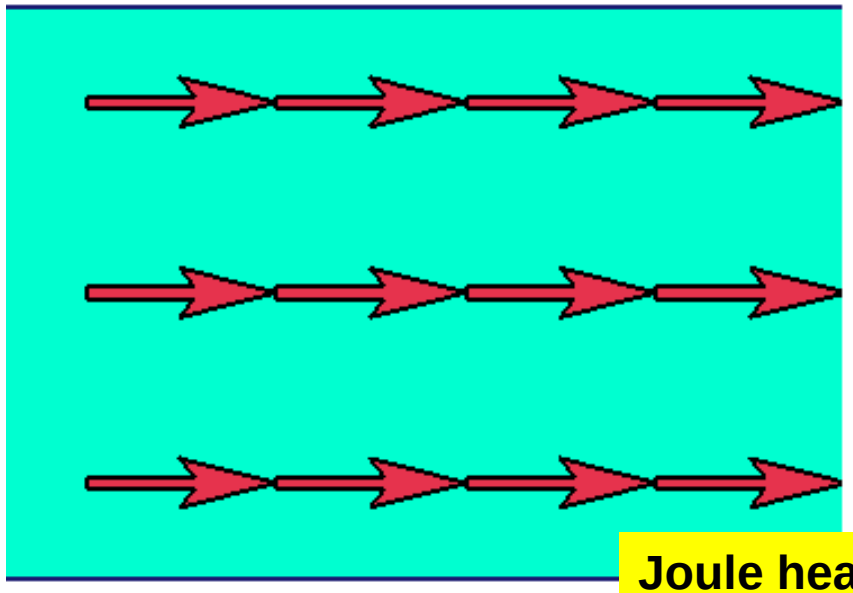
DC Conduction > Steady-state heat transfer

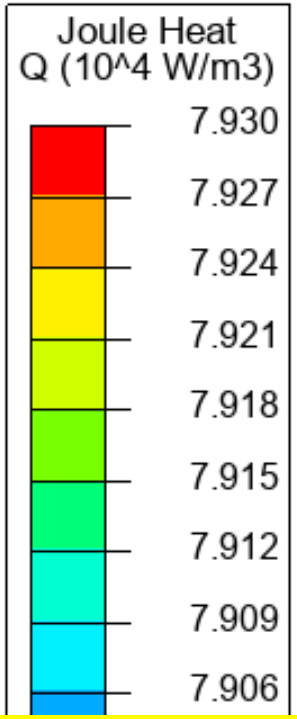
Temperature

https://quickfield.com/advanced/temperature_dependent_resistance.htm

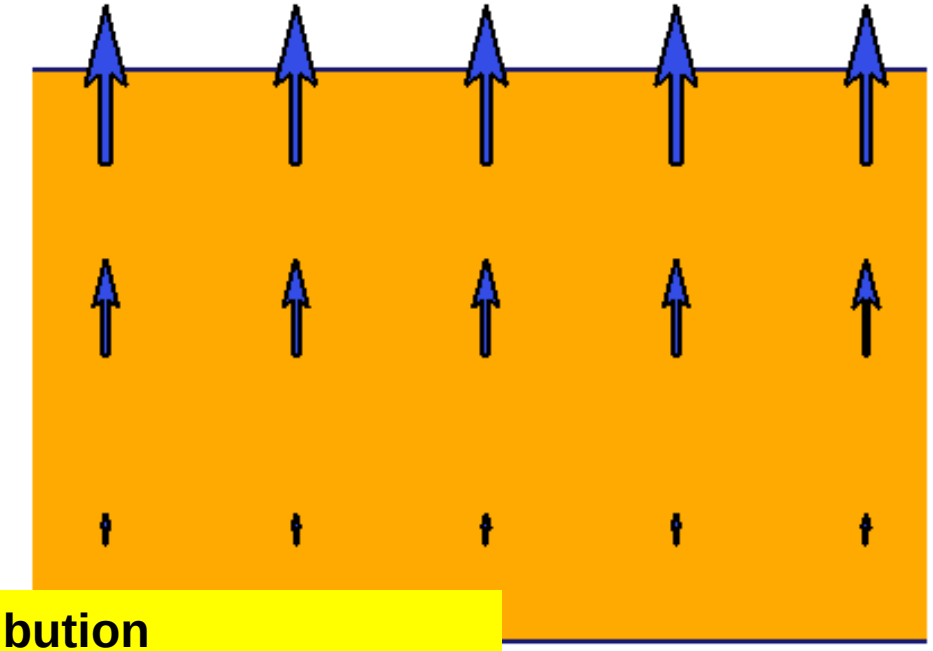
Temperature dependent electrical resistance

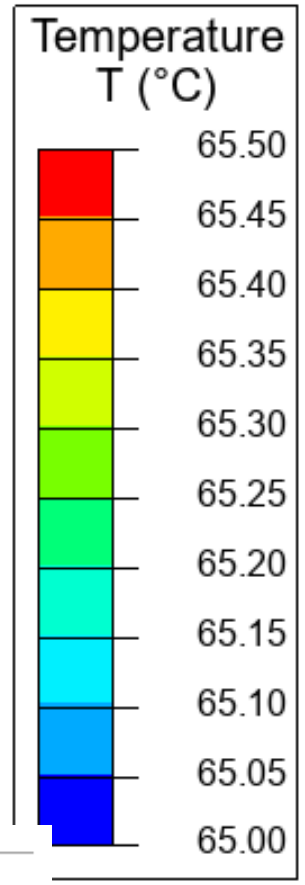
Problem Type	DC Conduction
Model Class	Axisymmetric





Problem Type	Steady-State Heat Transfer
Model Class	Axisymmetric





Joule heat power distribution

DC Conduction > Steady-state heat transfer

Conductivity σ, S/m	31700100
Joule Heat Q, W/m^3	79112.9
Strength E, V/m	
Current Density J, A/m^2	
|J|	1583630

Volume V, mm^3	6314.74
Cross section area S_c, mm^2	30.0006
Physical Quantities	
Heat flux Φ, W	
Φ	0.491522

Temperature

https://quickfield.com/advanced/temperature_dependent_resistance.htm

This recording is over

More recordings and simulation examples at www.quickfield.com

Your feedback is welcome: support@quickfield.com