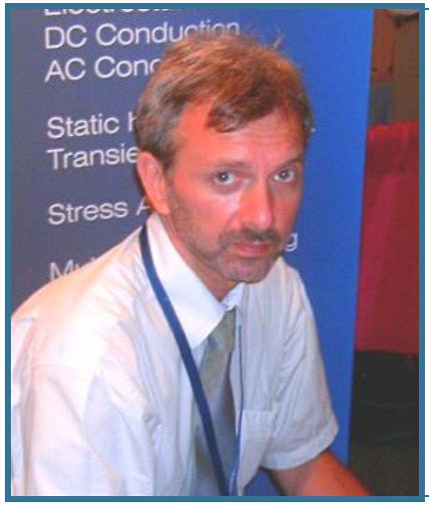
Induction motors simulation with QuickField



Vladimir Podnos

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Tera Analysis Ltd.

Alexander Lyubimtsev

Support Engineer
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https://quickfield.com/seminar/seminar_induction_motors.htm

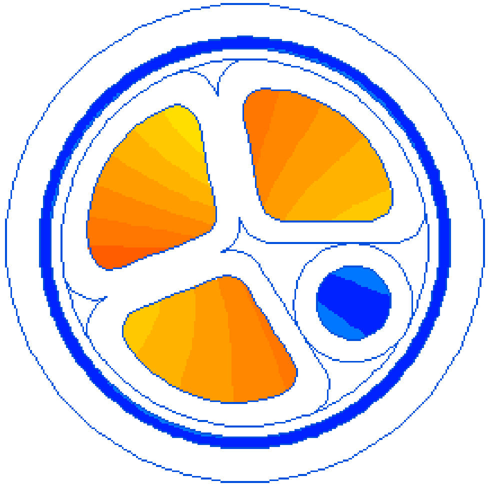
QuickField Analysis Options

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

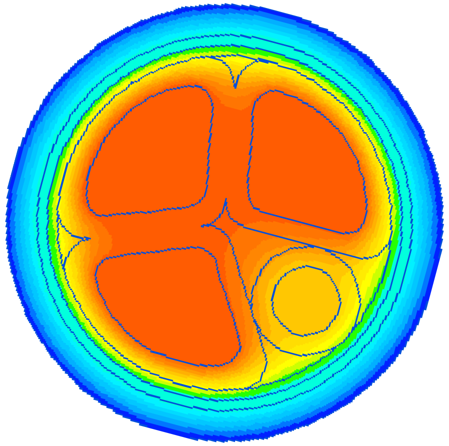
MultiPhysics (2D)

Electromagnetic fields



Losses →

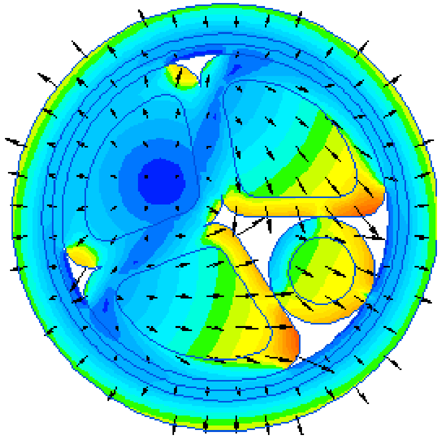
Temperature field



Temperature field import

Magnetic state import

Forces

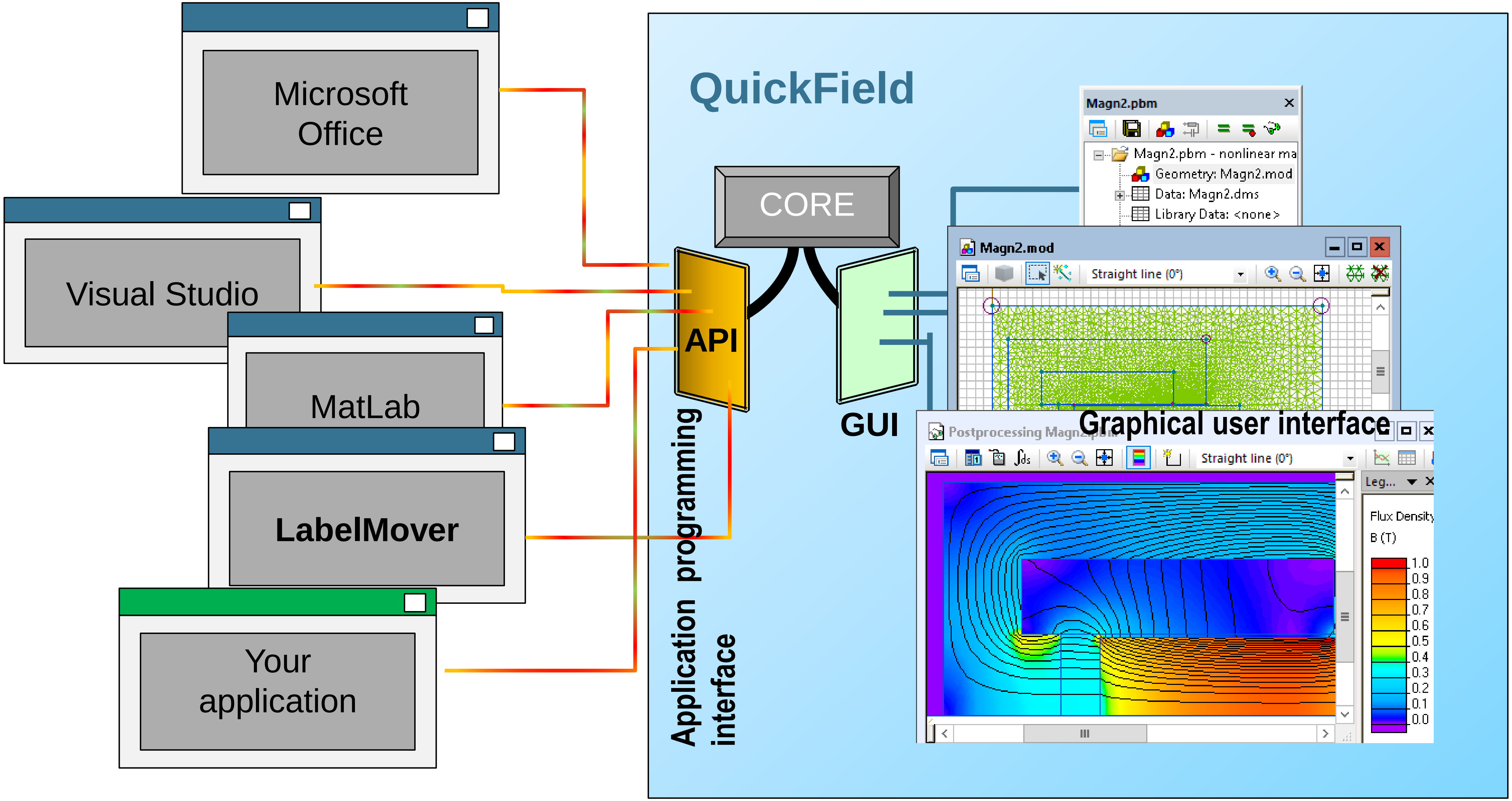


Thermal Stresses

Stresses & Deformations

https://quickfield.com/coupling.htm

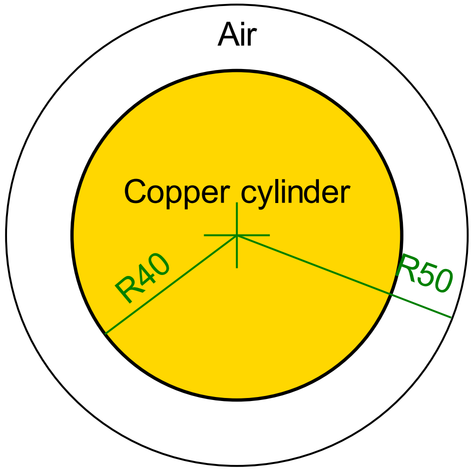
QuickField API



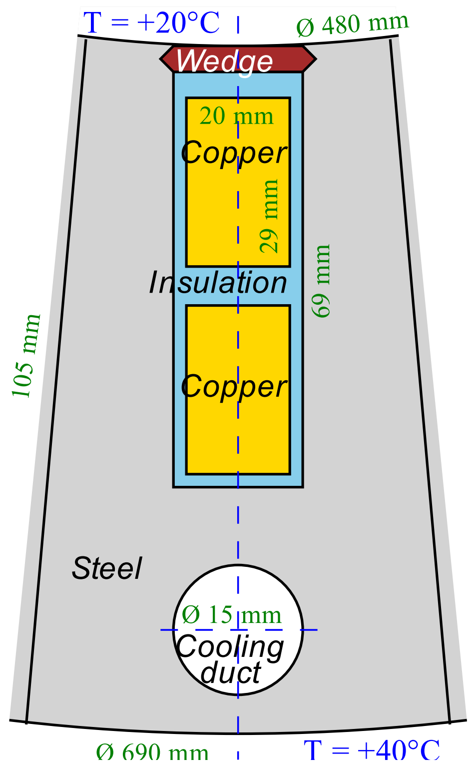
https://quickfield.com/programming.htm

QuickField Difference

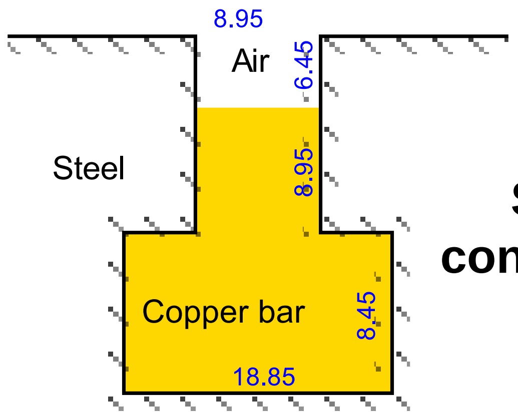
Induction motors simulation with QuickField



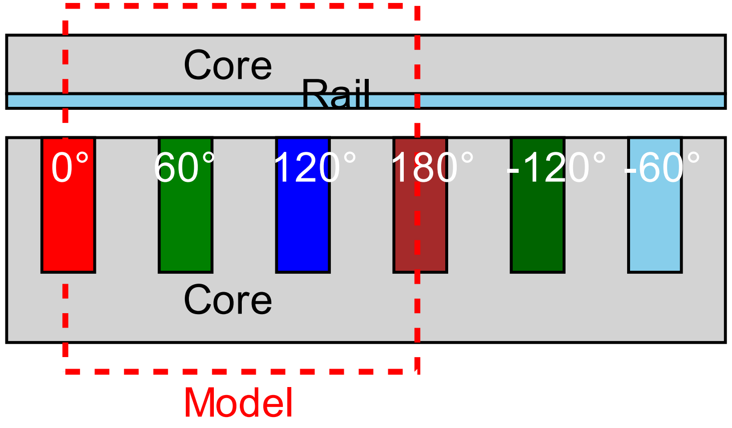
Rotating magnetic field boundary condition



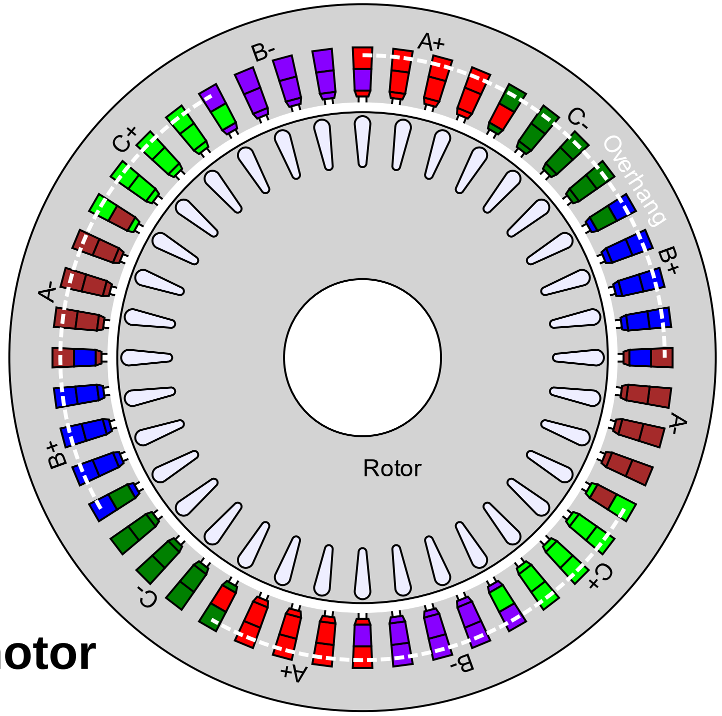
Slot heating



Slot embedded conductor skin effect



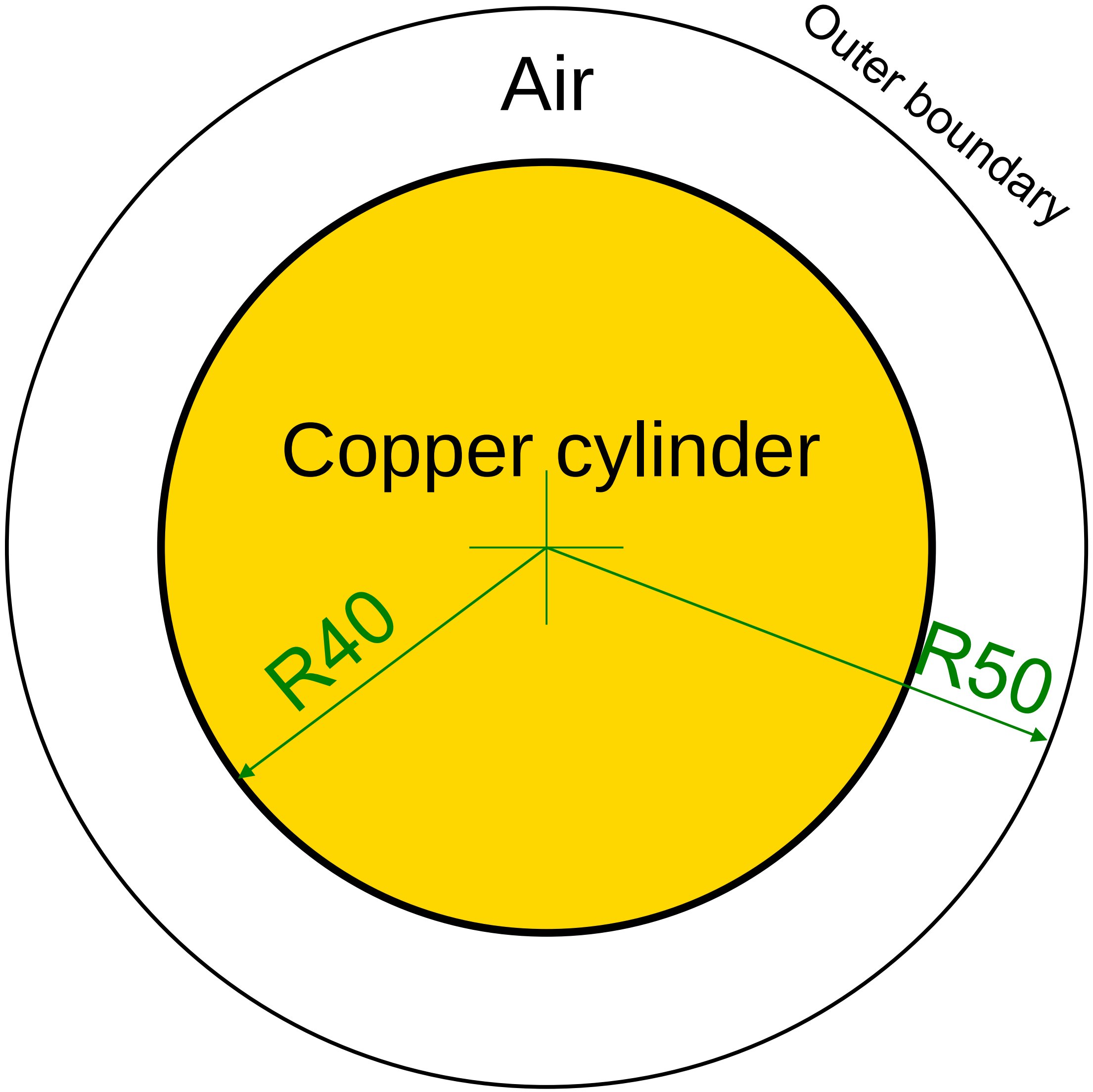
Linear electric motor



Induction motor

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

Rotating magnetic field boundary condition



Problem specification:

Stator produces sinusoidal rotating magnetic field.

Copper conductivity σ = 63 MS/m;
Number of poles 2p = 2;
Frequency f = 60 Hz.

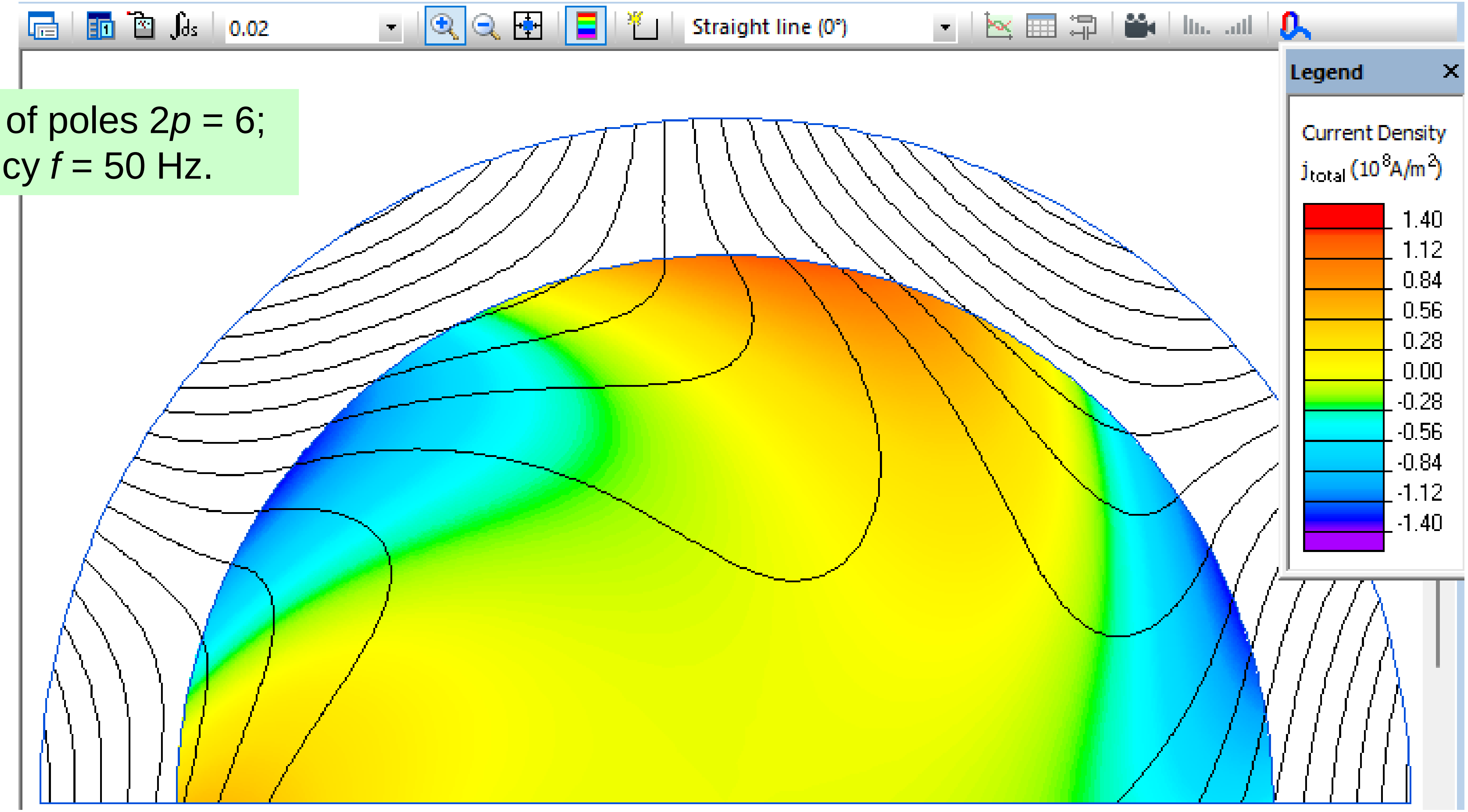
Task:

Calculate the torque and rotor heating.

https://quickfield.com/advanced/dirich1.htm

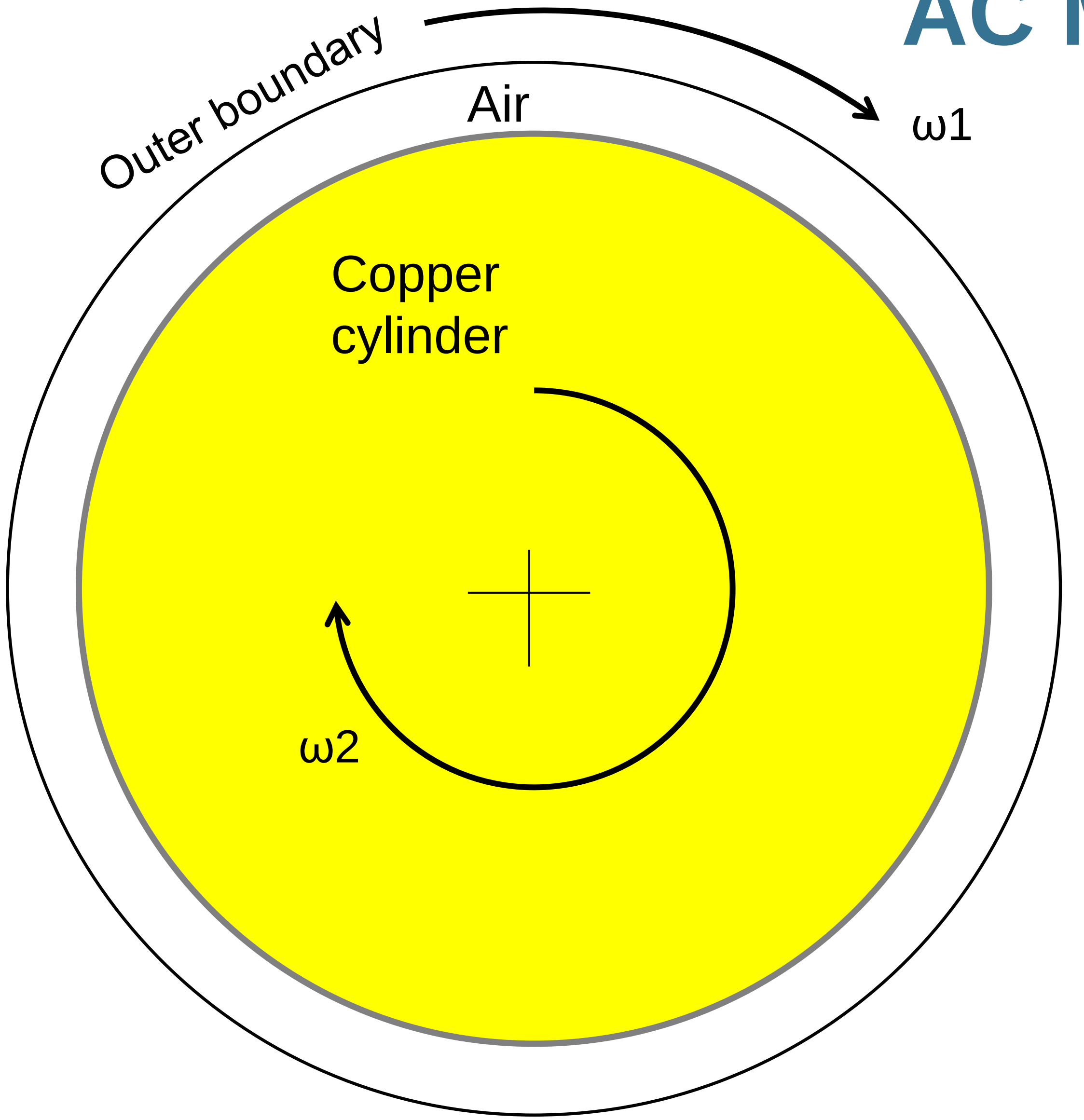
Rotating magnetic field boundary condition

Number of poles $2p = 6$;
Frequency $f = 50$ Hz.



https://quickfield.com/advanced/dirich1.htm

Rotating magnetic field boundary condition
AC Magnetics



Problem specification:

Stator produces sinusoidal rotating magnetic field with angular velocity ω1

Rotor angular velocity ω2

Task:

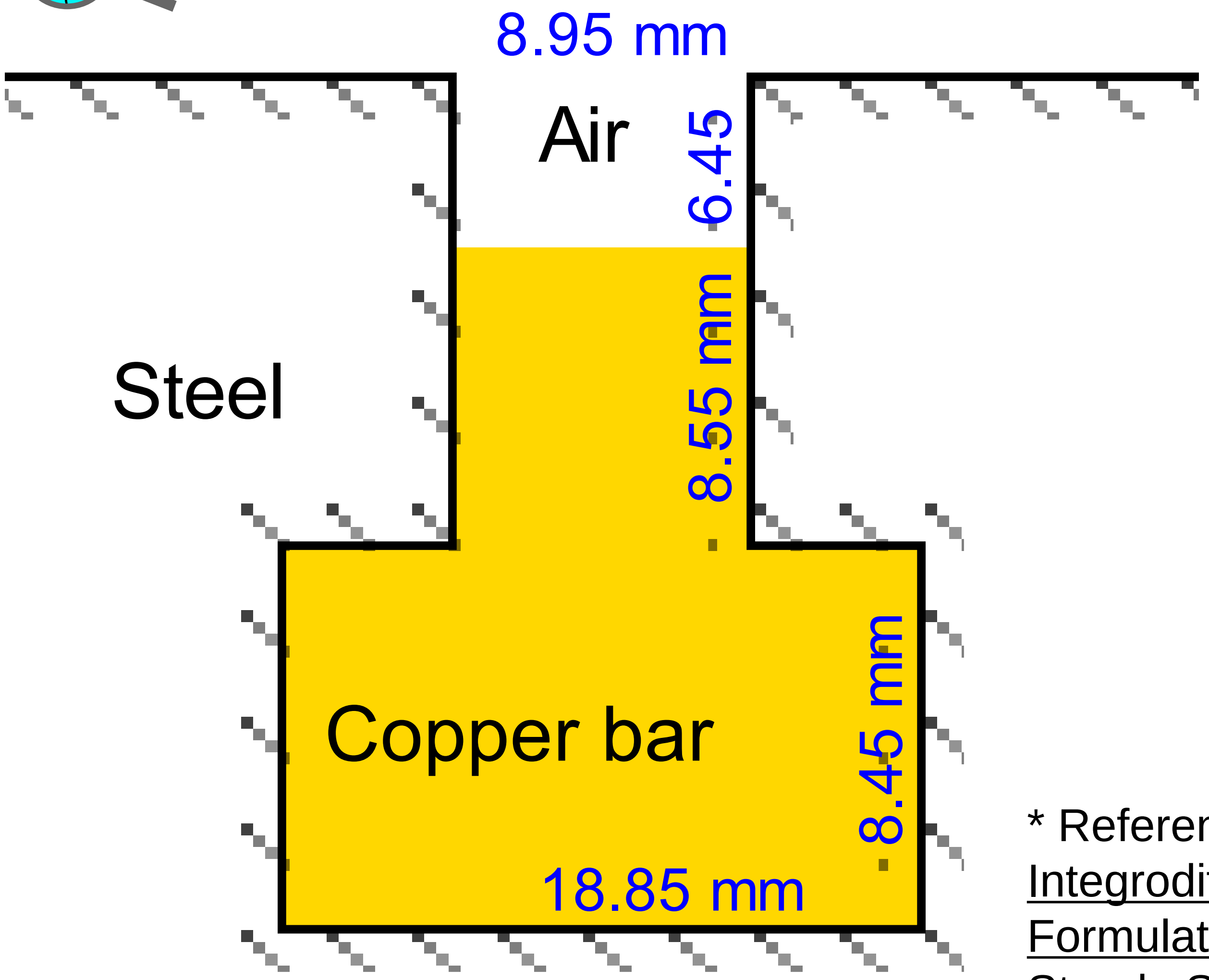
Calculate the torque and rotor heating.

https://quickfield.com/glossary/rotating_magnetic_field.htm

Rotating magnetic field boundary condition.
AC Magnetics

https://quickfield.com/glossary/rotating_magnetic_field.htm

Slot embedded conductor skin effect



All dimensions are in millimeters

Problem specification:

Conductivity of copper σ = 58 MS/m

Current in the conductor *I* = 1 A

Frequency *f* = 45 Hz

Task:

Determine current distribution within the conductor and complex impedance of the conductor.

* Reference: A. Konrad, Integrodifferential Finite Element Formulation of Two-Dimensional Steady-State Skin Effect Problems, IEEE Trans. Magnetics, Vol MAG-18, # 1, January 1982.

https://quickfield.com/advanced/hmagn1.htm

Slot embedded conductor skin effect

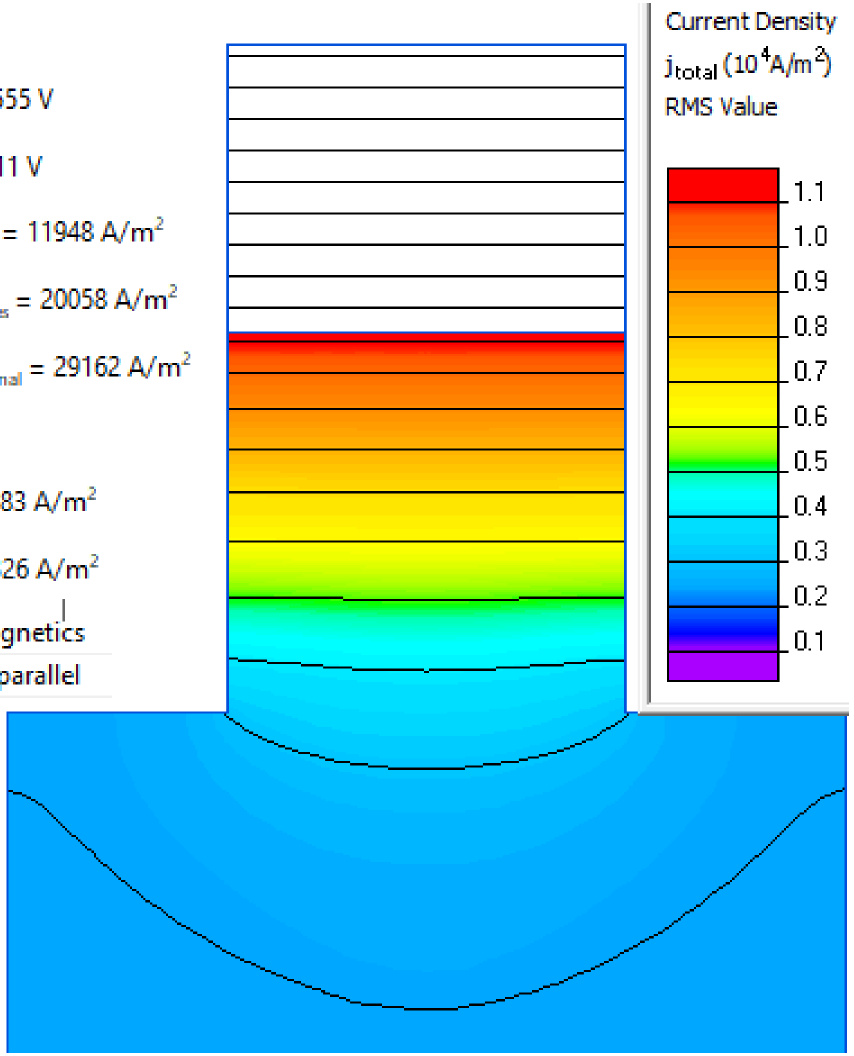
|Z| Voltage V = 0.00050275 V
- φ = 69.562 °
- Re(V) = 0.00017555 V
- Im(V) = 0.0004711 V

|Z| Current Density j_{total} = 11948 A/m²

|Z| Current Density j_{eddies} = 20058 A/m²

|Z| Current Density $j_{external}$ = 29162 A/m²
- φ = 69.562 °
- Re($j_{external}$) = 10183 A/m²
- Im($j_{external}$) = 27326 A/m²

Problem Type	AC Magnetics
Model Class	Plane-parallel
Z Length (L_z), mm	1000
Frequency, Hz	45



	External current density, A/m²
QuickField	10183 + j27326
Reference*	10182.7 + j27327.9

* Reference: A. Konrad, Integrodifferential Finite Element Formulation of Two-Dimensional Steady-State Skin Effect Problems, IEEE Trans. Magnetics, Vol MAG-18, # 1, January 1982.

Values

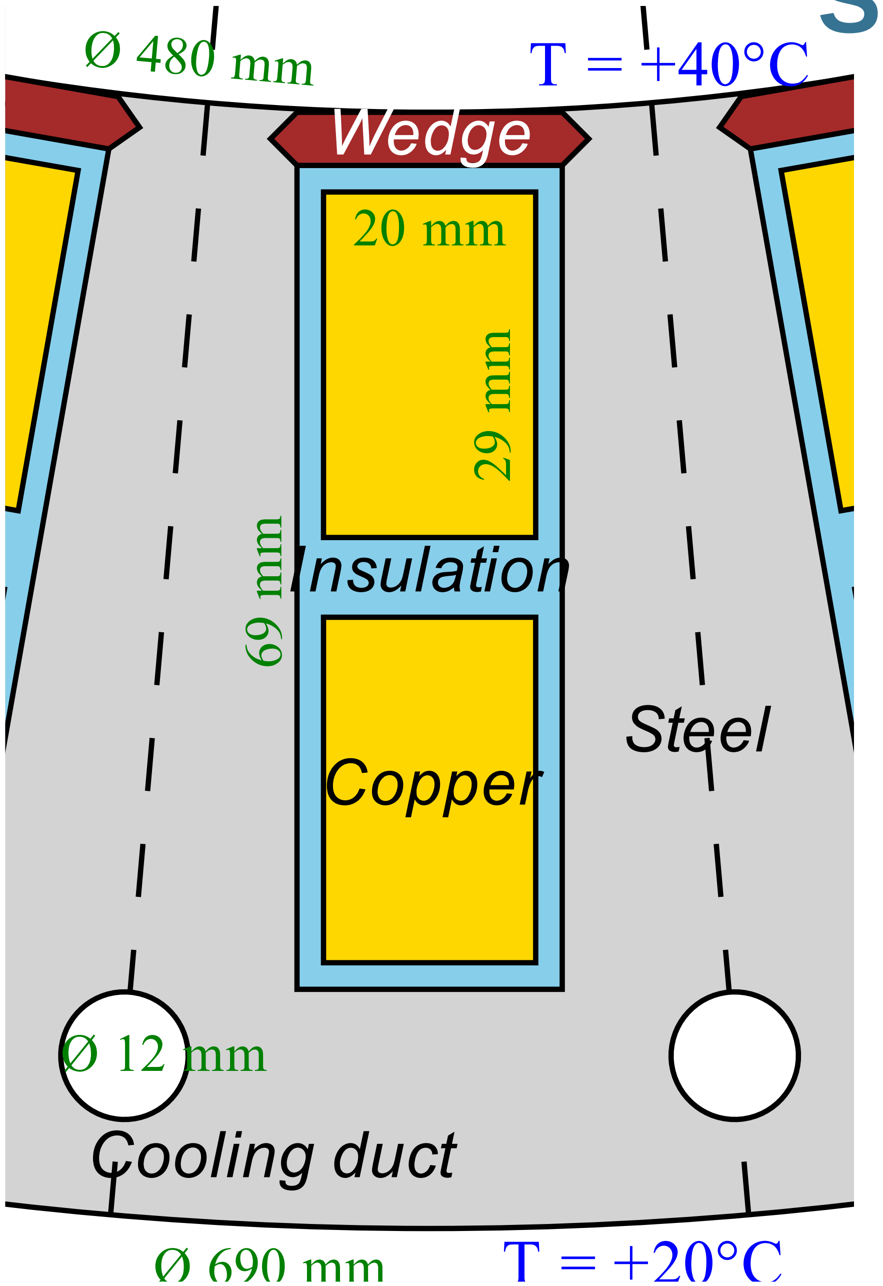
Impedance Wizard

|Z| Impedance: Z = 0.00050275 (Ω)
- Resistance: R = 0.00017555 (Ω)
- Reactance: X_L = 0.0004711 (Ω)

Inductance: L = 1.6662e-6 (H)

https://quickfield.com/advanced/hmagn1.htm

Slot heating



Problem specification:

Specific copper loss $Q = \rho*j*j$ =160 kW/m³;
Thermal conductivity of materials: insulation 0.15 W/K-m, copper 380 W/K-m, steel 25 W/K-m, wedge 0.25 W/K-m.

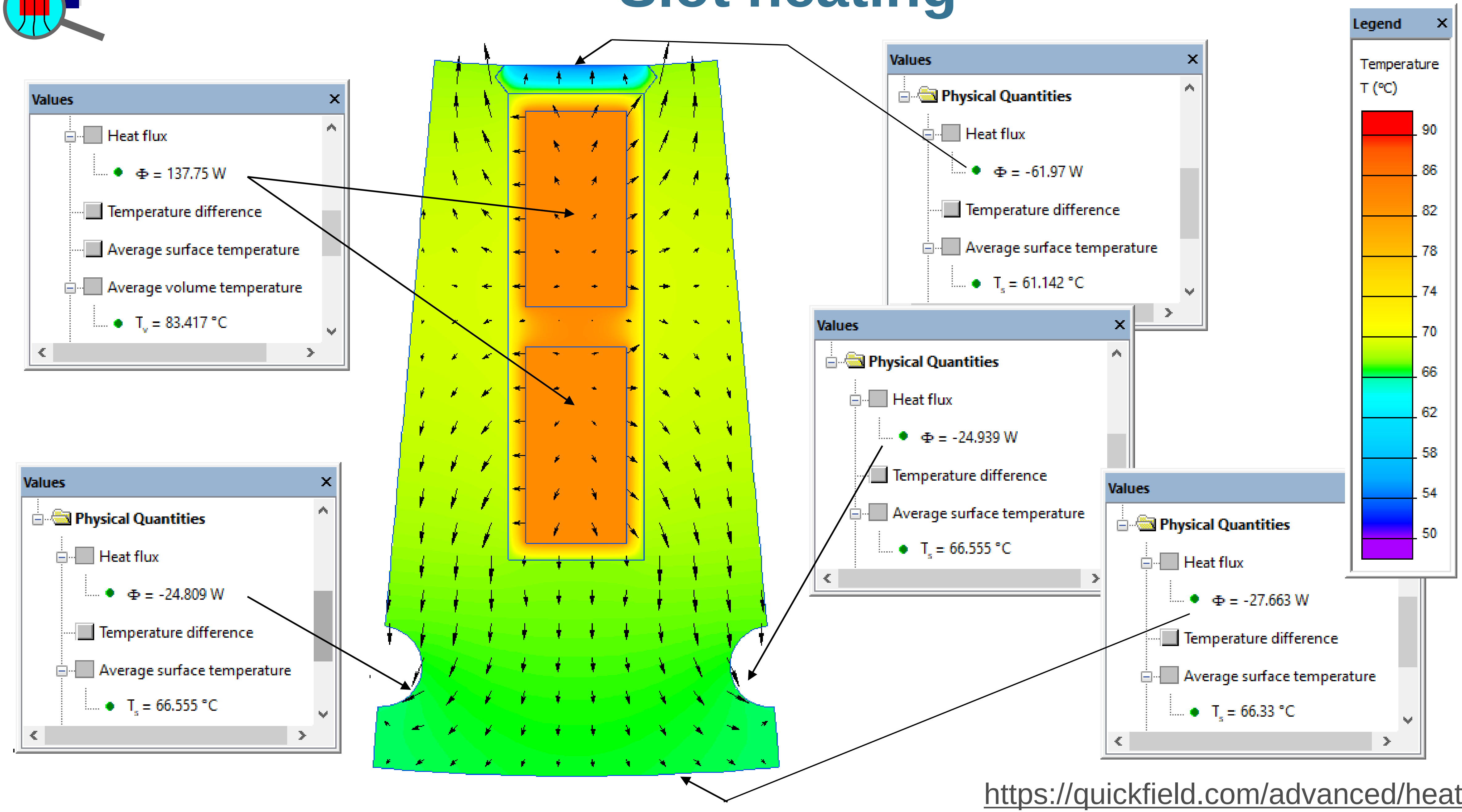
Convection coefficient: outer surface 10 W/K-m²,
inner surface 70 W/K-m² , cooling duct 50 W/K-m²

Task:

Calculate temperature distribution in the stator tooth zone of an electric machine.

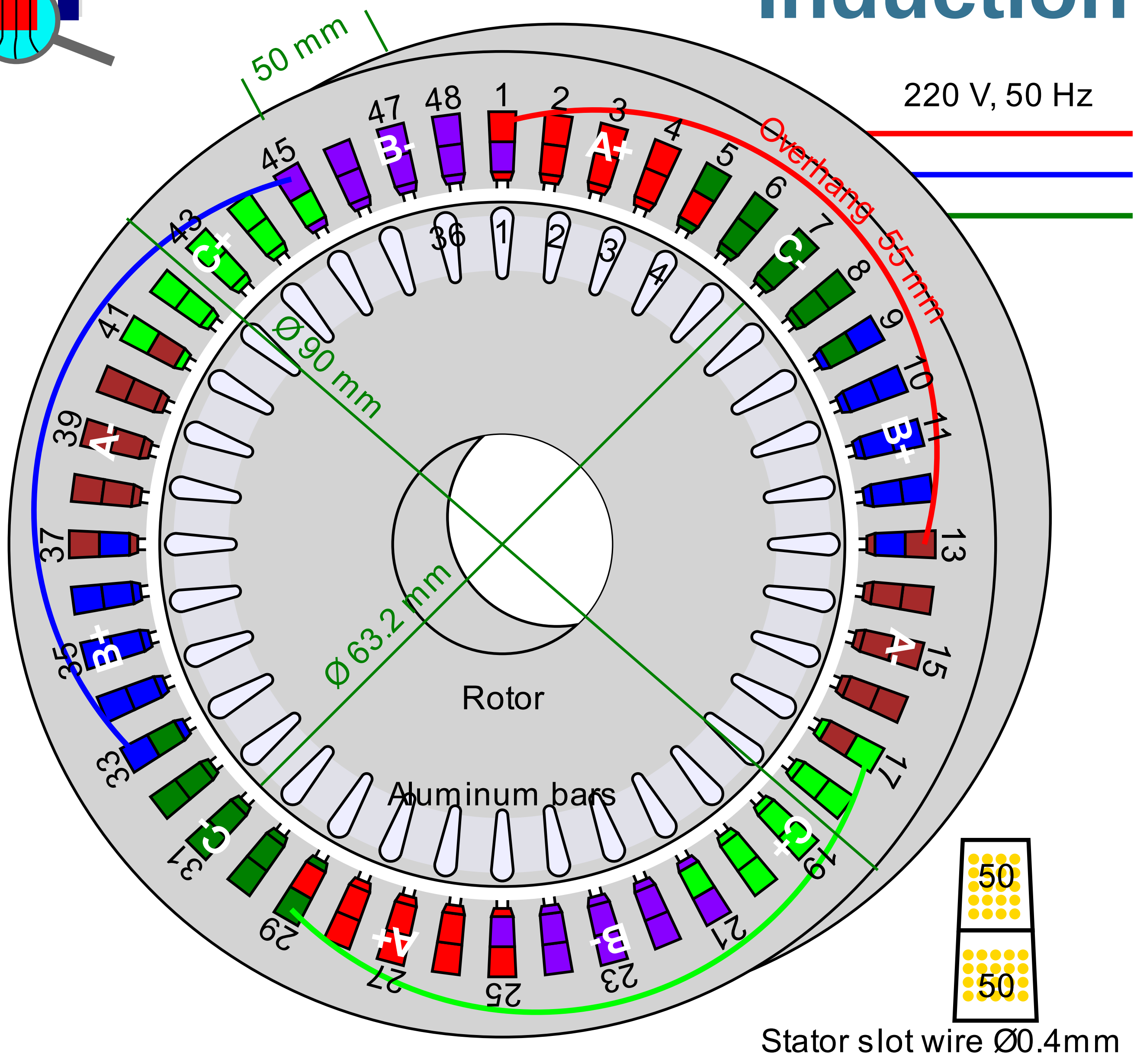
https://quickfield.com/advanced/heat1.htm

Slot heating



https://quickfield.com/advanced/heat1.htm

Induction motor



Problem specification:

Conductivity of copper σ_1 = 46.8 MS/m;

Conductivity of aluminum σ_2 = 31.1 MS/m;

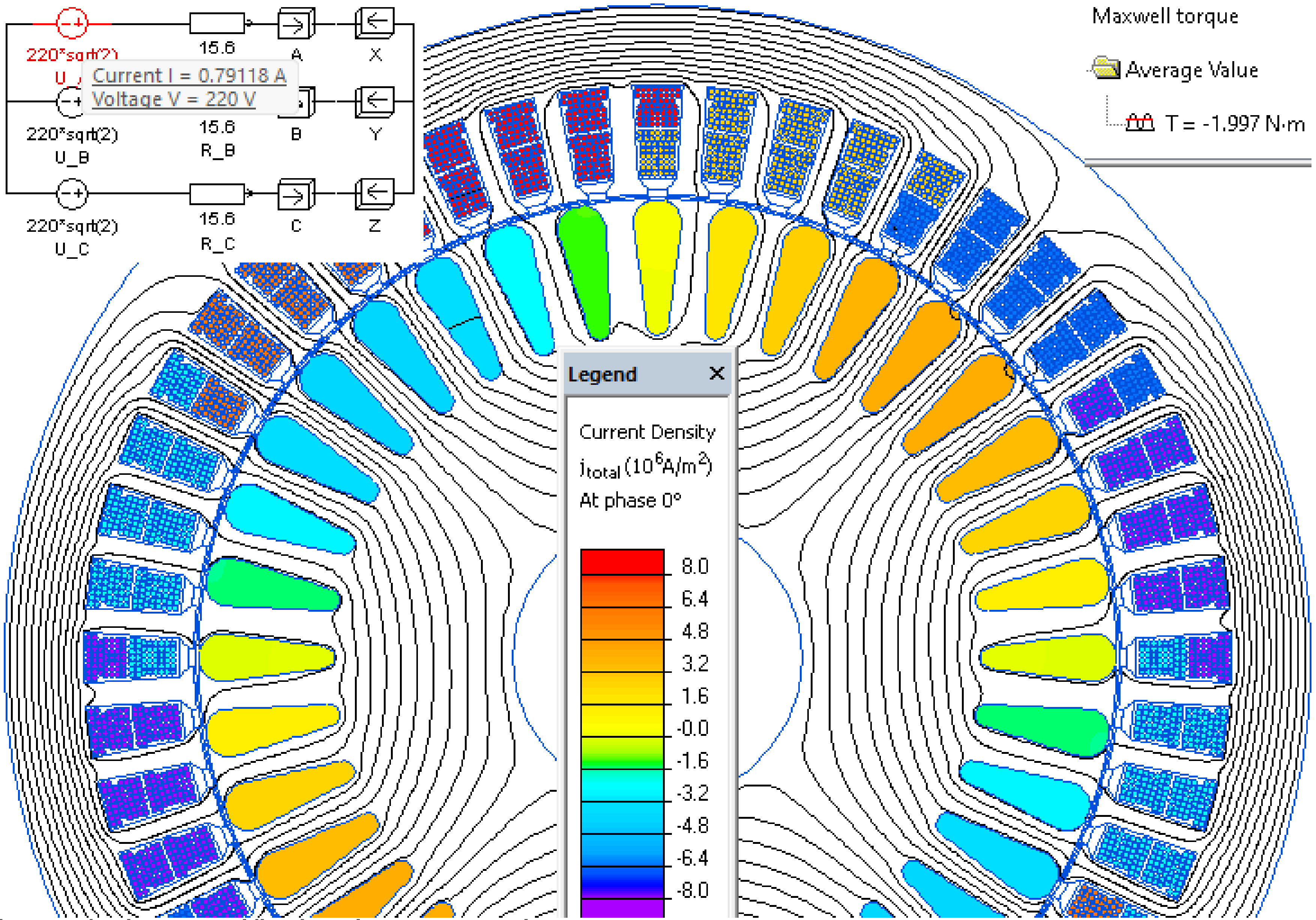
Task:

Calculate torque, current, Joule heat losses in the rotor at various rotation speeds

Rotation velocity	Rotor currents	Bar conductivity in the model
0 - stall		σ_2
Slip: $0<n<n_0$		$\sigma_2 * (1 - n / n_0)$
Synchronous	0	0

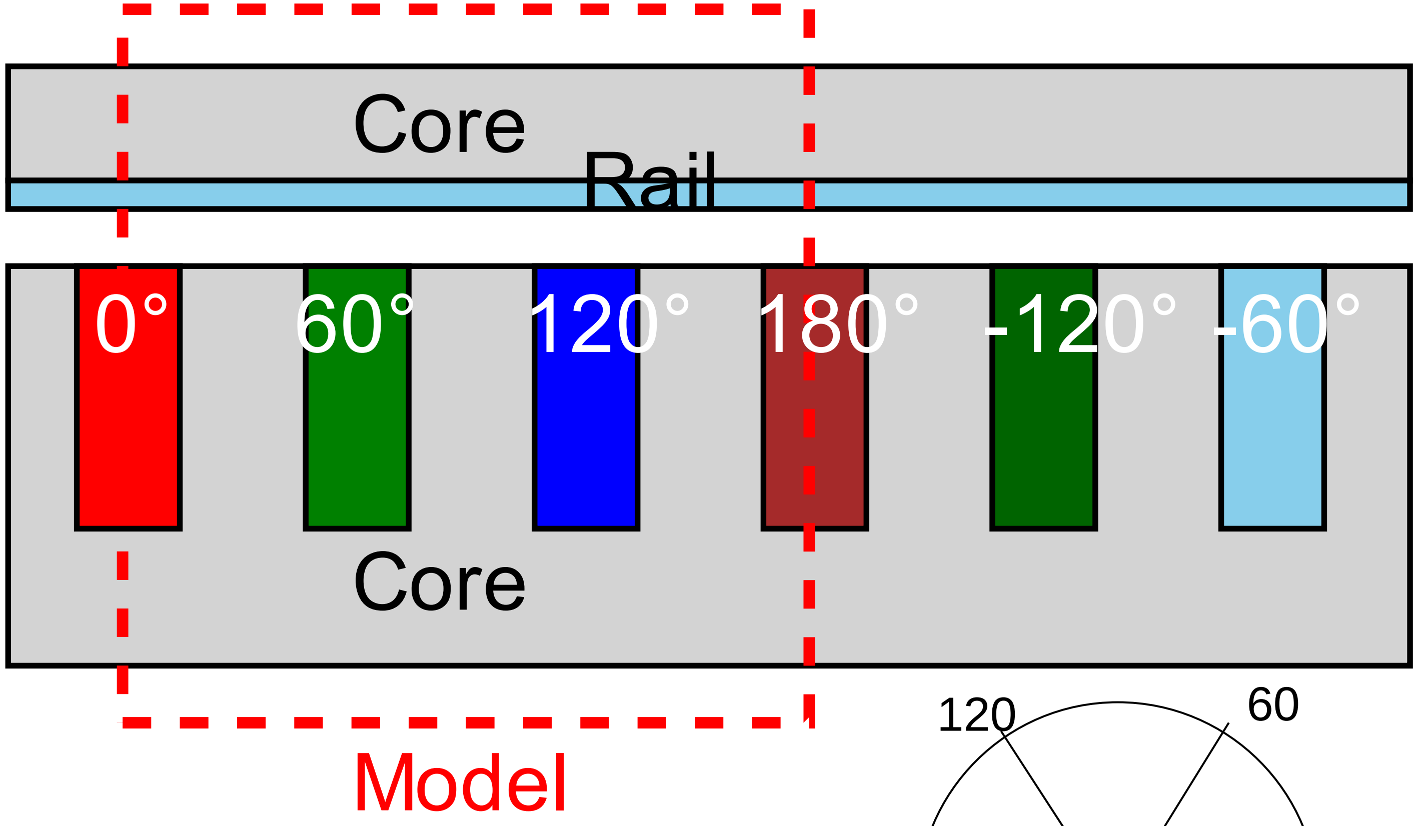
https://quickfield.com/advanced/induction_motor.htm

Induction motor



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

Linear electric motor



Problem specification:

Core magnetic permeability μ = 1000;

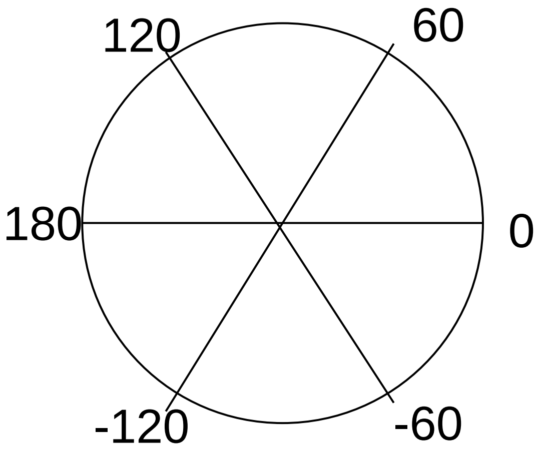
Rail conductivity σ = 33 MS/m;

Frequency *f* = 50 Hz.

Slot total current I = 1844 A (r.m.s)

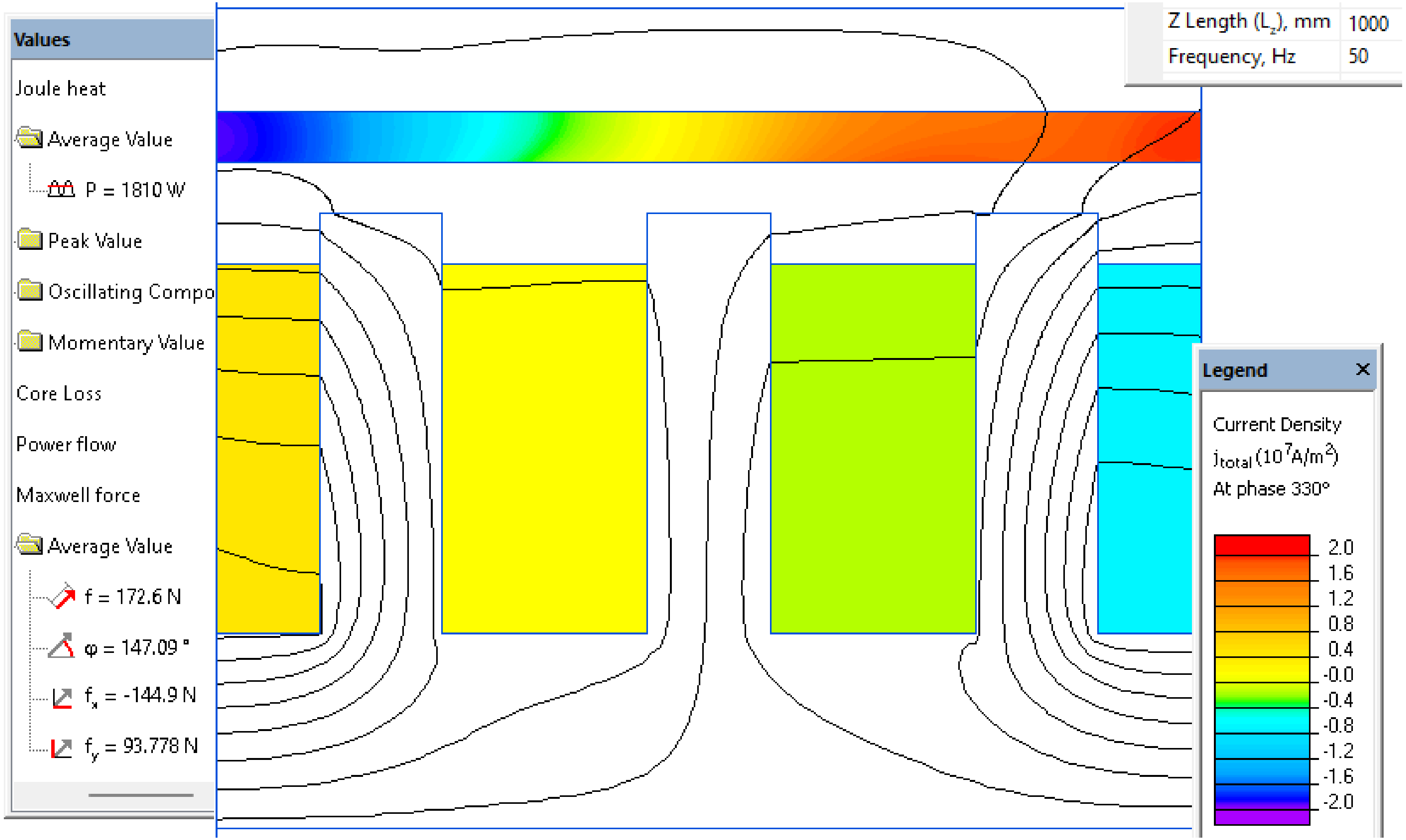
Task:

Calculate propulsion force acting on the rail and Joule heat losses



https://quickfield.com/advanced/perio2.htm

Linear electric motor



https://quickfield.com/advanced/perio2.htm

This recording is over

More recordings and simulation examples at www.quickfield.com

Your feedback is welcome: support@quickfield.com