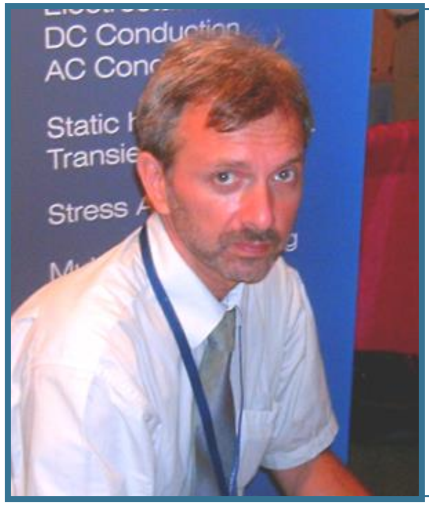
Synchronous generators simulation with QuickField



Vladimir Podnos

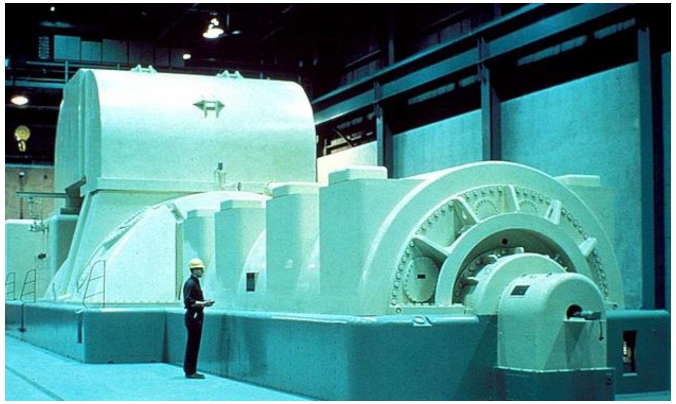
Director of Marketing and Support
Tera Analysis Ltd.

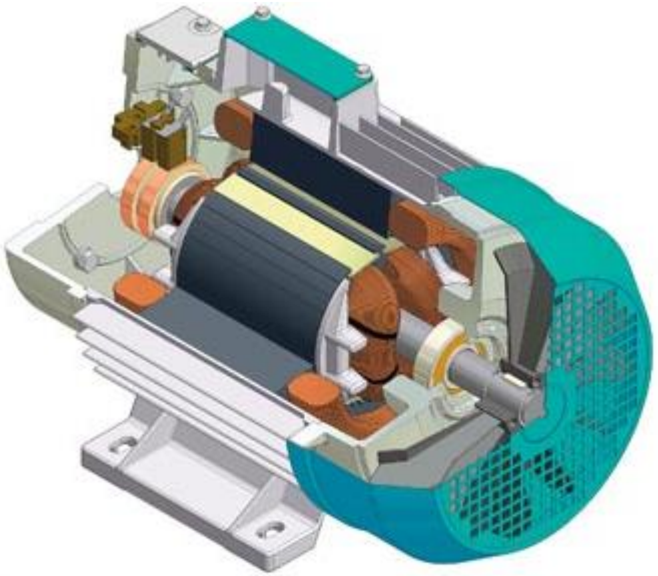
Alexander Lyubimtsev

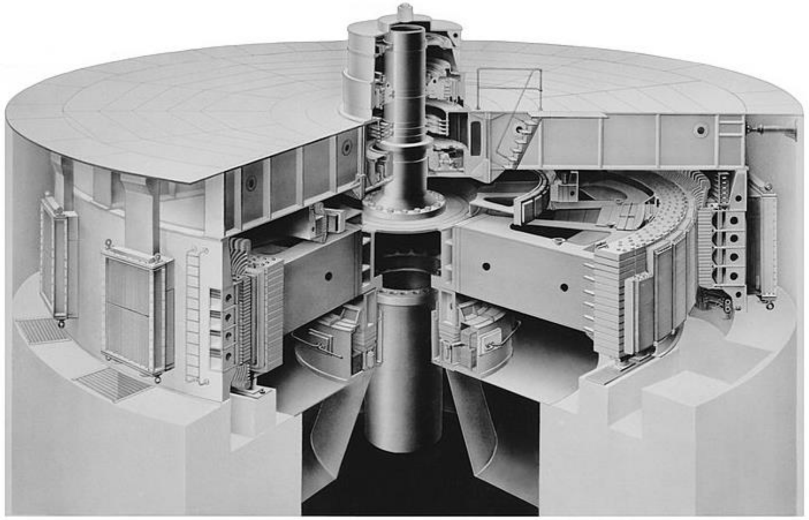
Support Engineer
Tera Analysis Ltd.

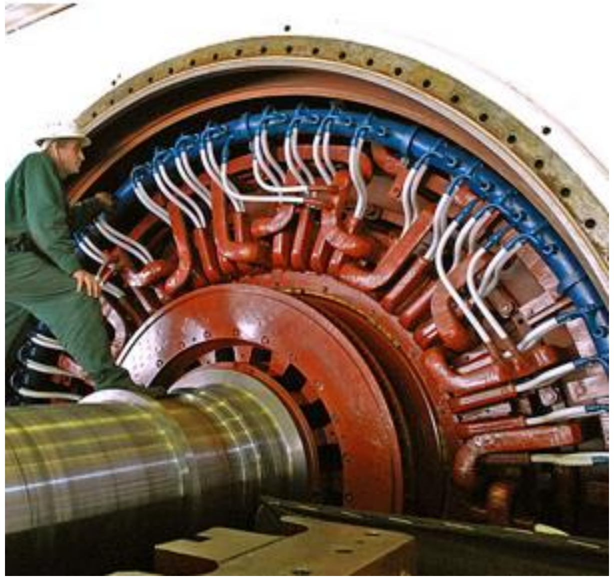
https://quickfield.com/seminar/seminar_synchronous_generators.htm

Synchronous generators







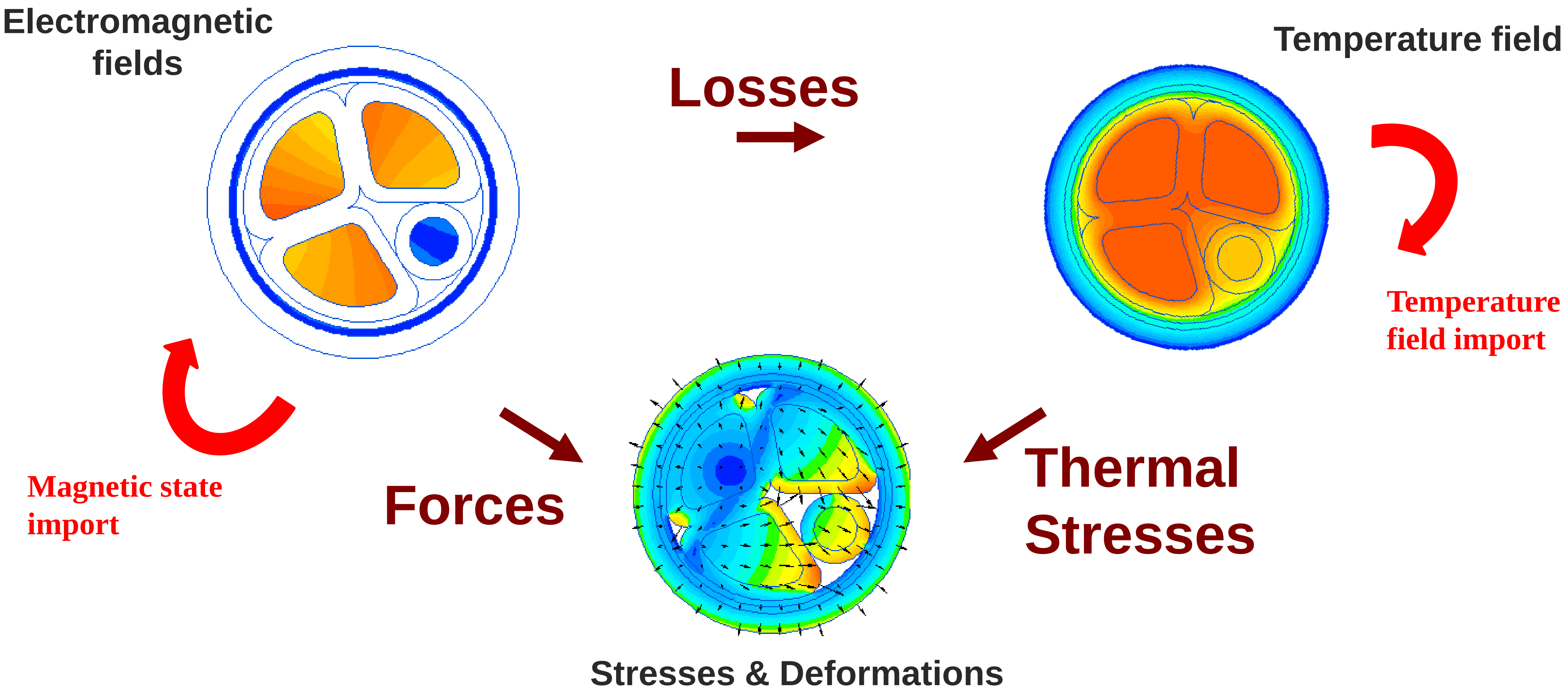


QuickField Analysis Options

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

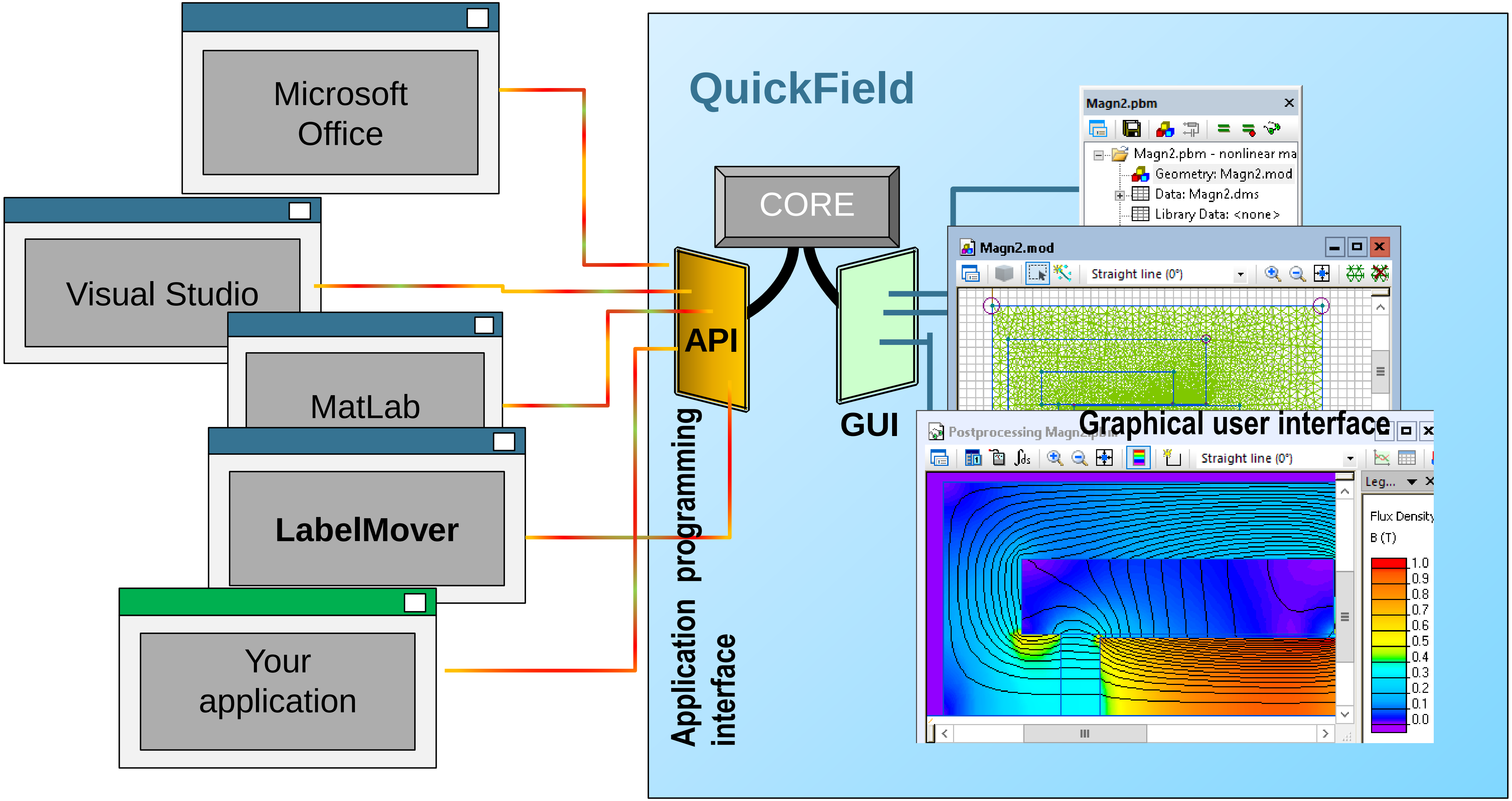
https://quickfield.com/pack.htm

MultiPhysics (2D)



https://quickfield.com/coupling.htm

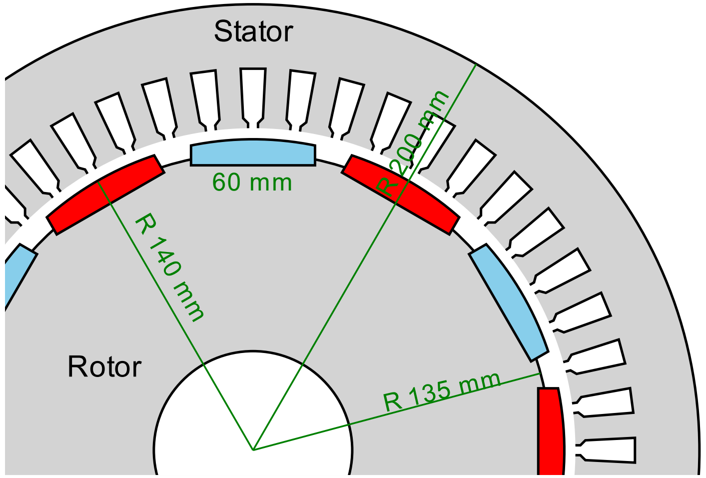
QuickField API



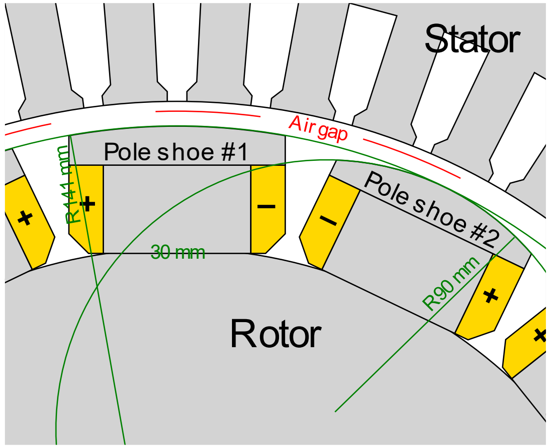
https://quickfield.com/programming.htm

QuickField Difference

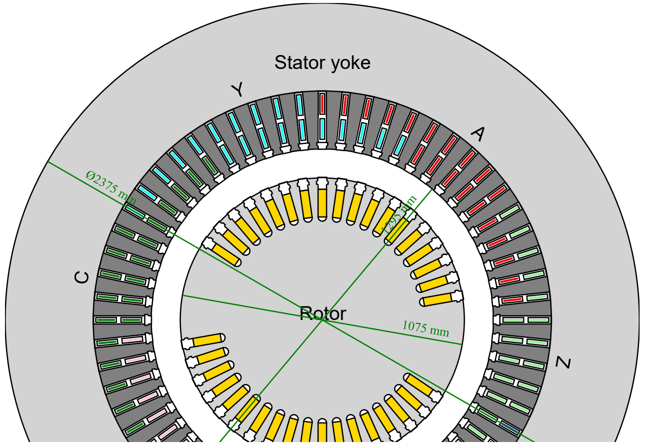
Synchronous generators simulation with QuickField



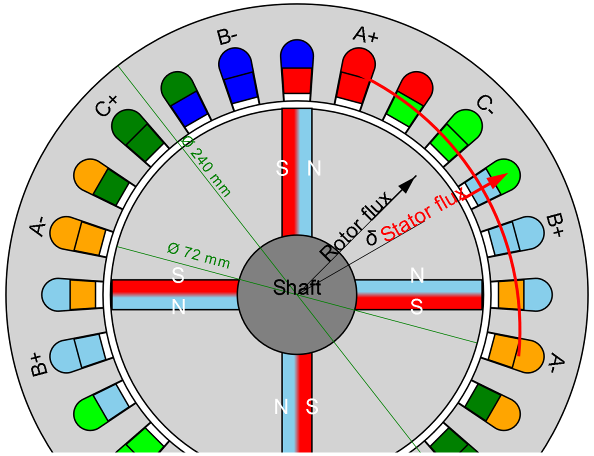
Cogging torque



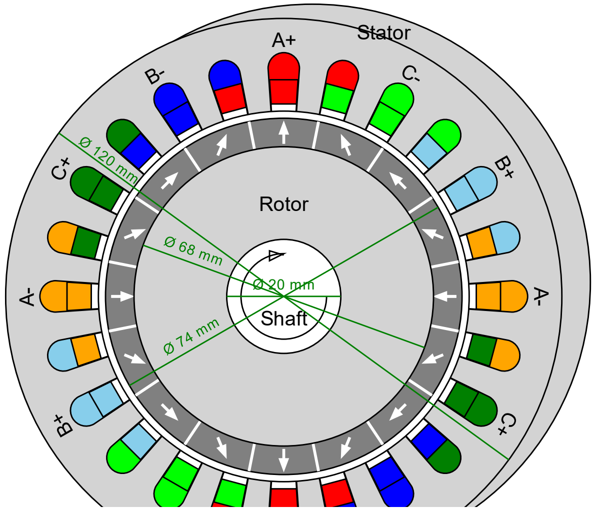
Pole shoe optimization



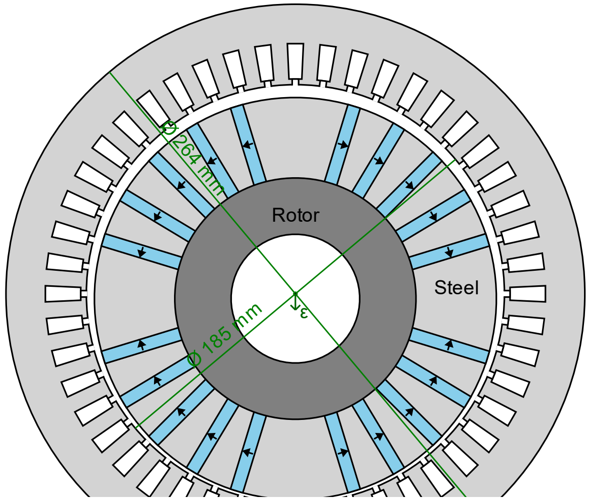
Turbine generator synchronous inductance



Synchronous machine power-angle curve



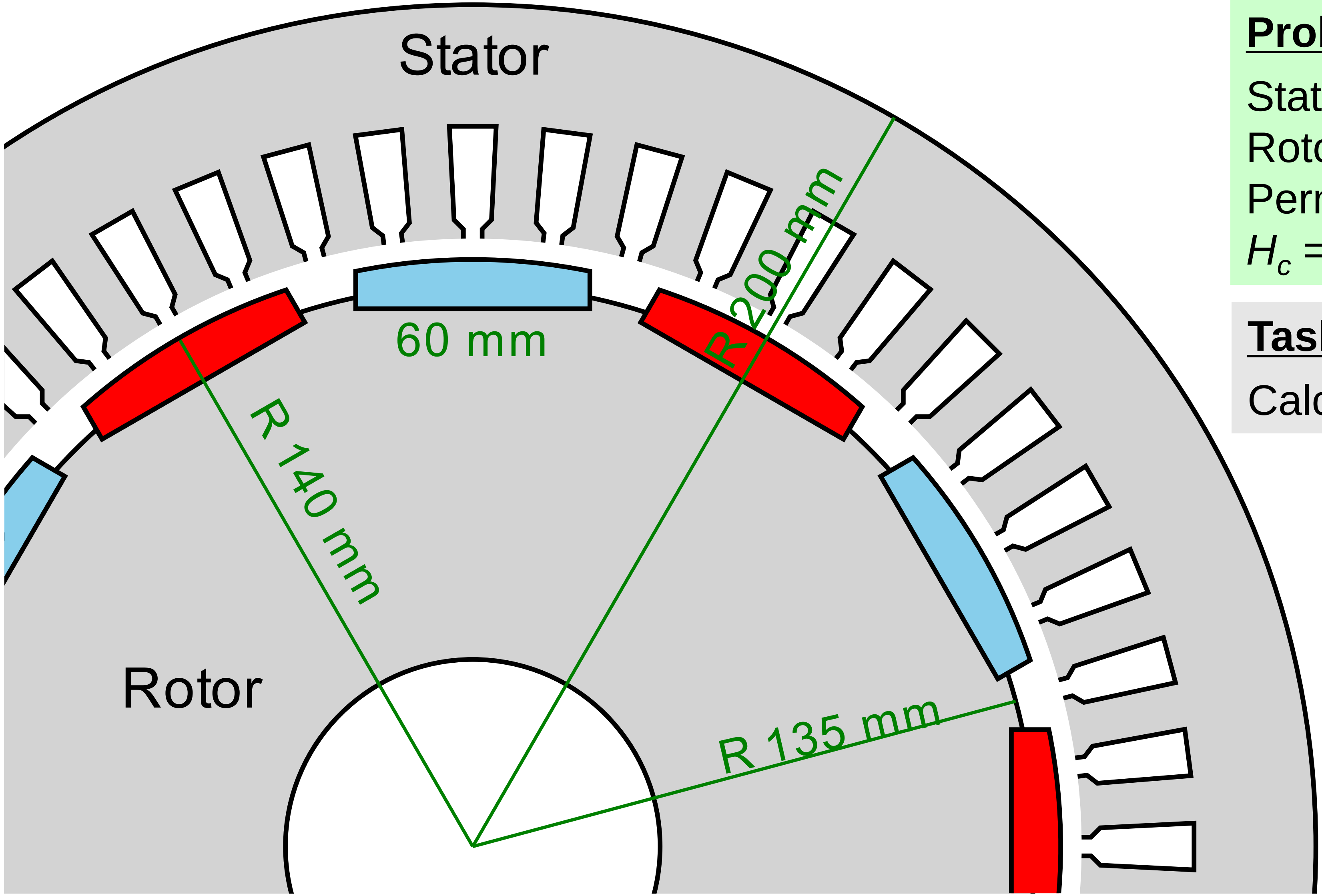
Halbach rotor generator



Unbalanced magnetic pull

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

Cogging torque



Problem specification:

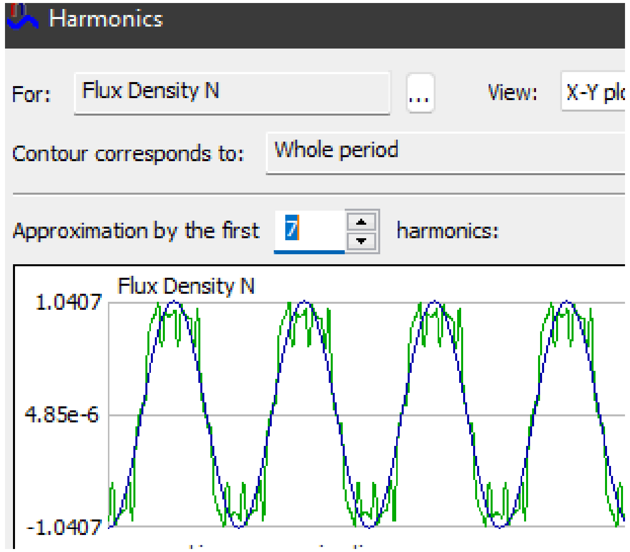
Stator slots number *Z1* = 48
Rotor poles number 2*p* = 12
Permanent magnet coercive force H_c = 950 kA/m

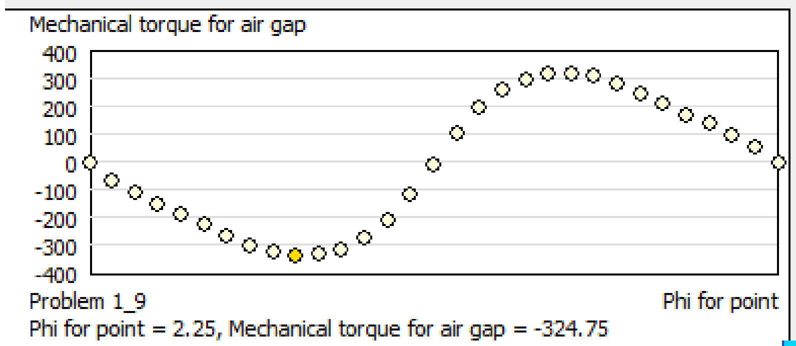
Task:

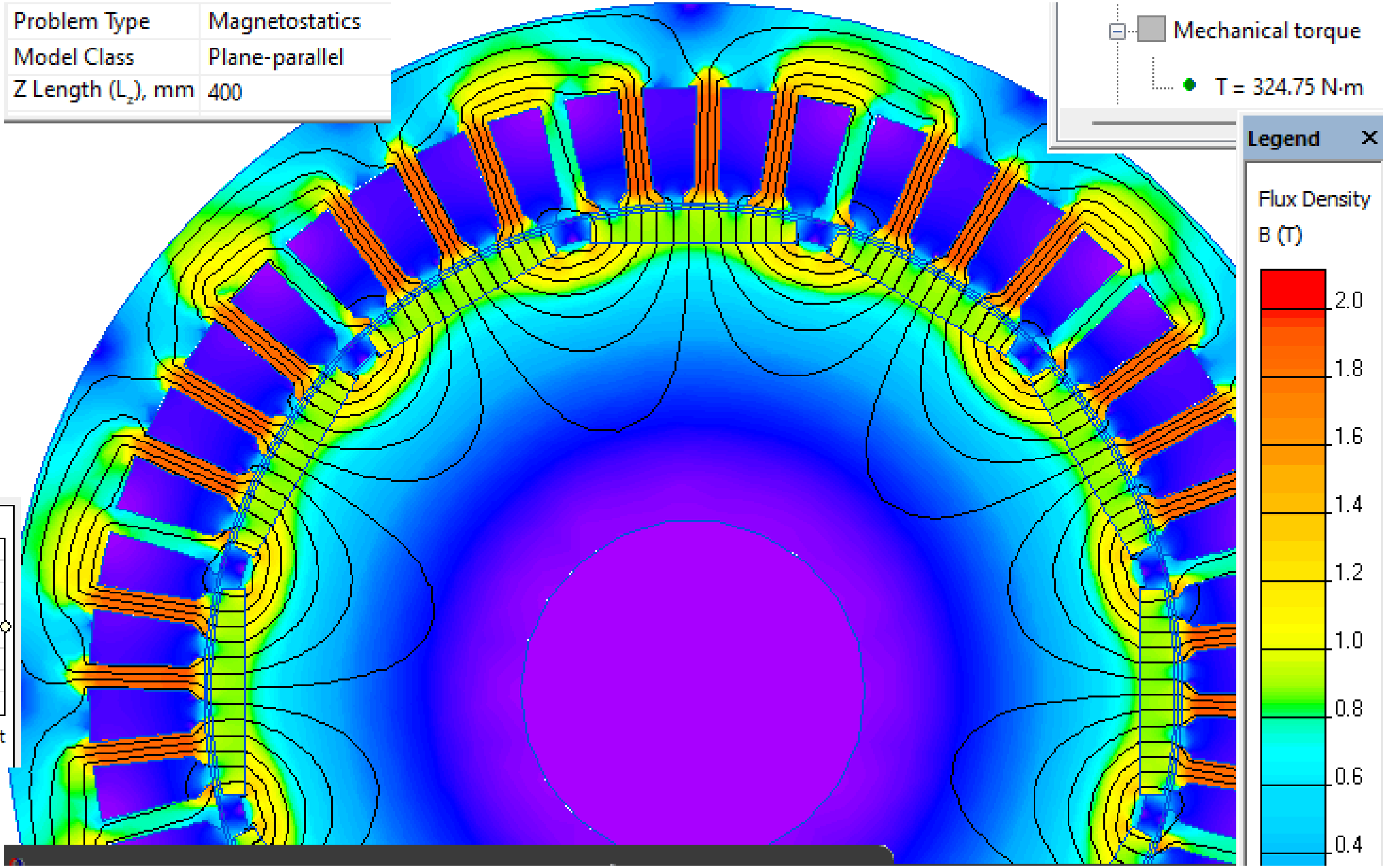
Calculate the cogging torque.

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

Cogging torque

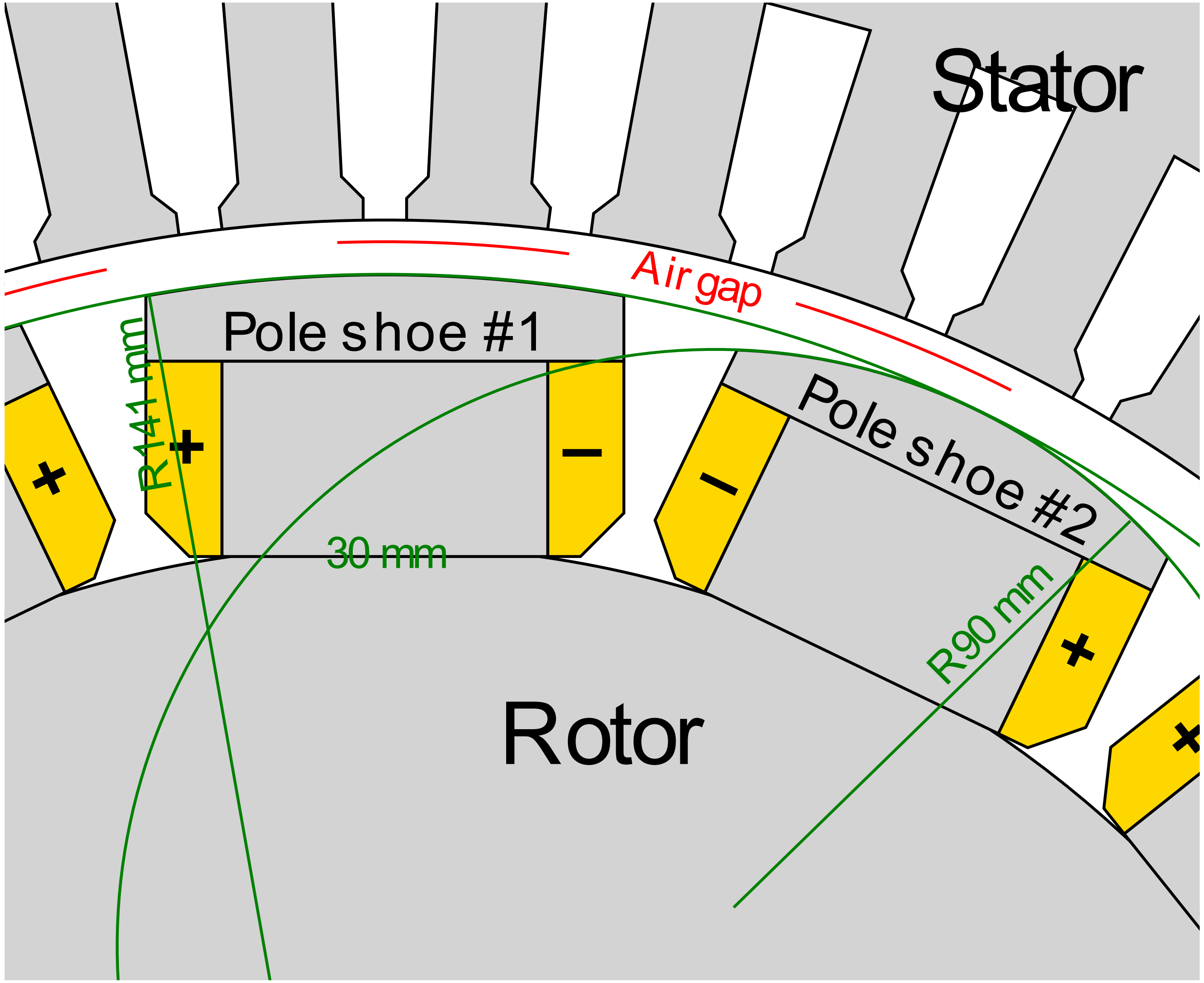






https://quickfield.com/advanced/cogging_torque.htm

Pole shoe optimization



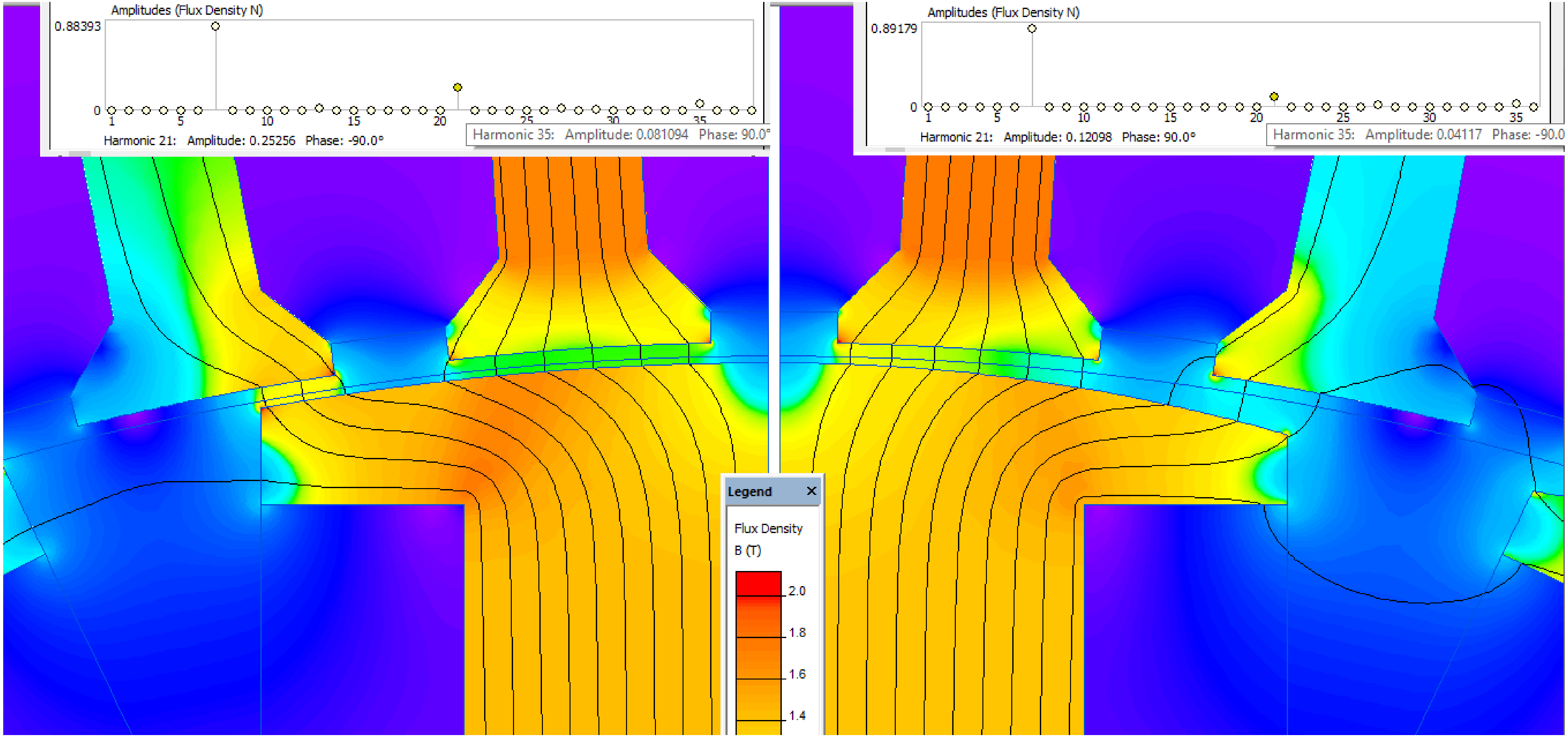
Problem specification:

Stator slots number *Z1* = 48
Rotor poles number 2*p* = 14
Current density *j* = 4 A/mm²

Task:

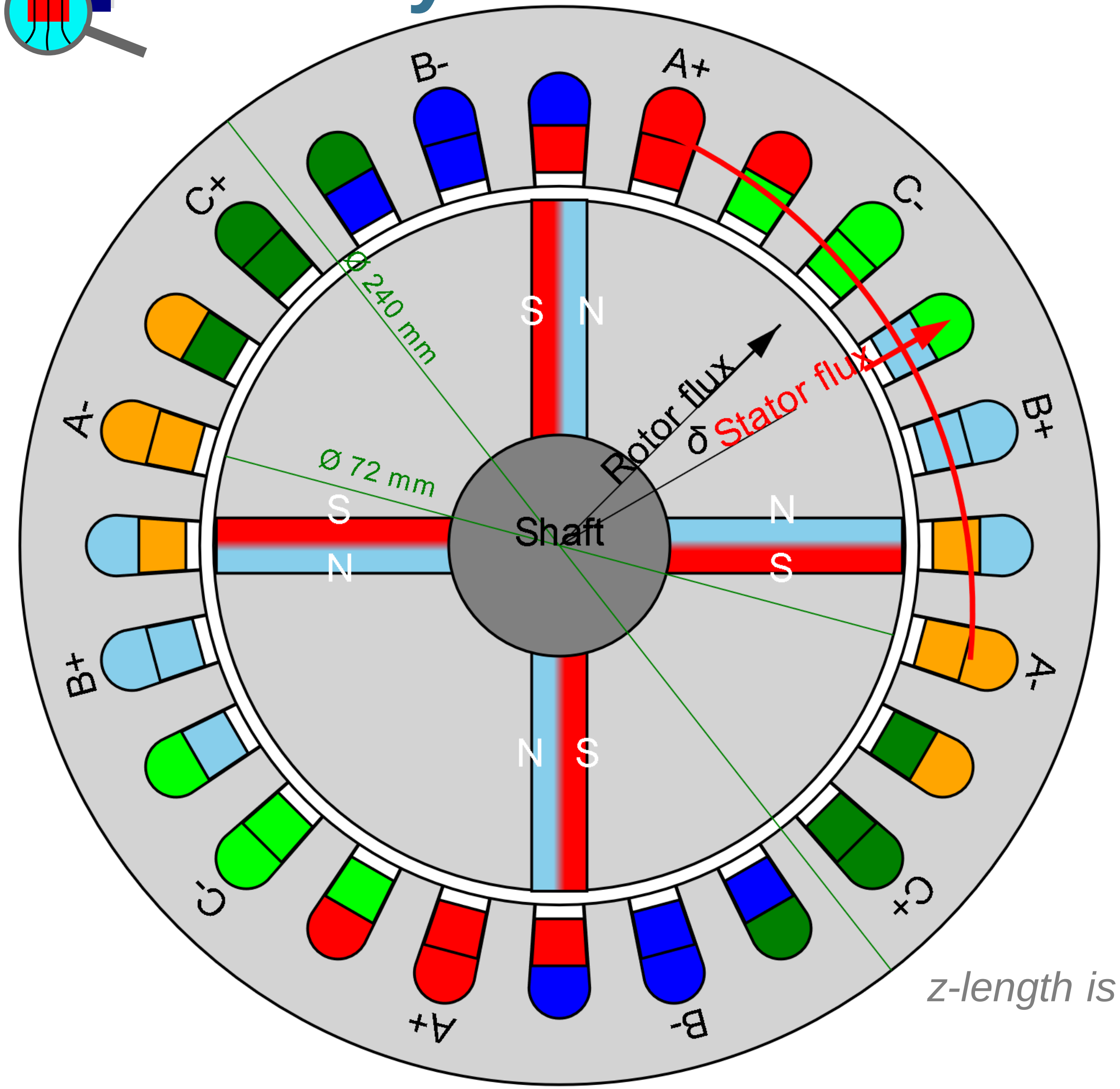
Calculate air gap flux density harmonics.

Pole shoe optimization



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

Synchronous machine power-angle curve



z-length is 65 mm

Problem specification:

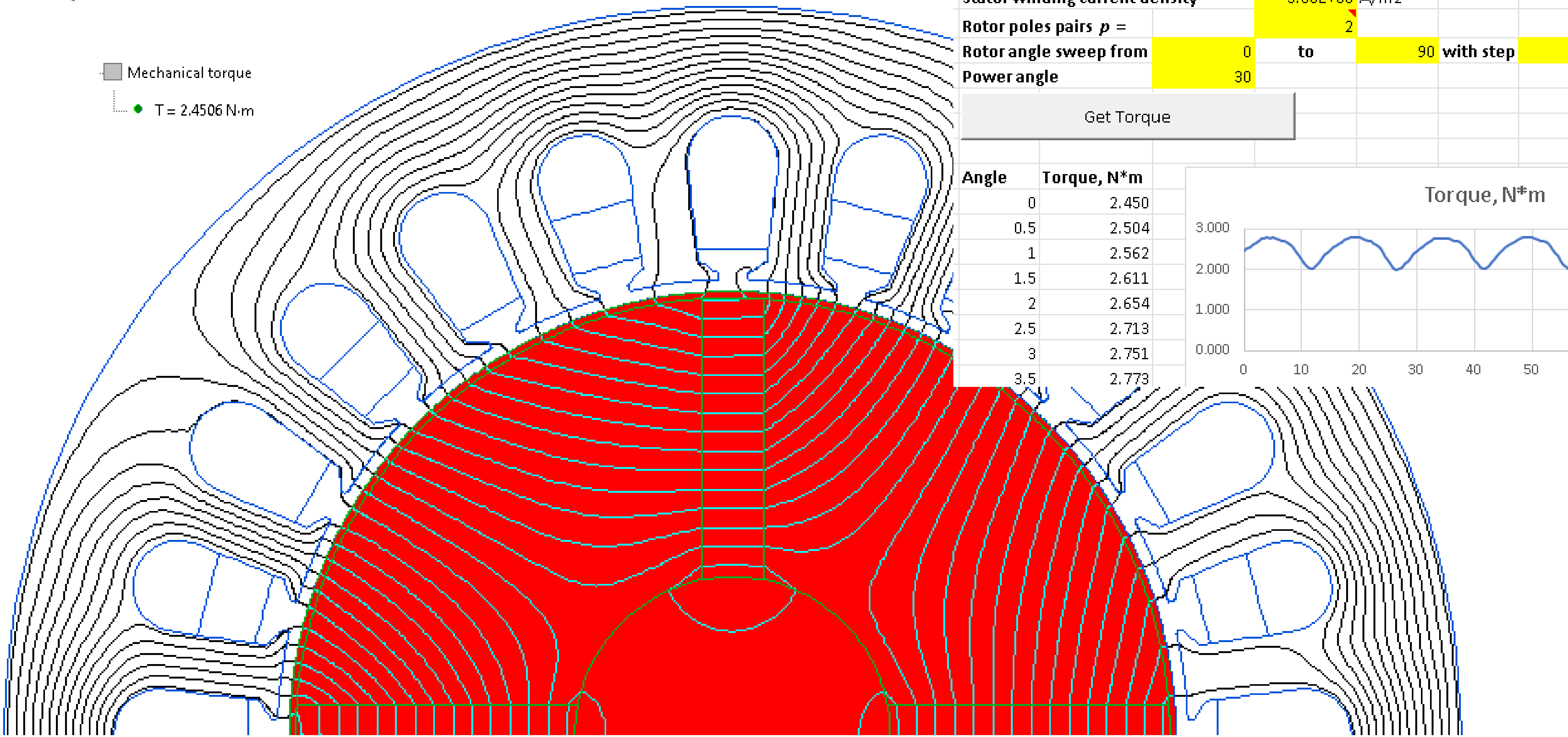
Phase current density j = 3 A/mm²
Coercive force of NdFeB permanent magnets H_c = 730 kA/m
Power angle δ = 30° (electrical degrees).

Task:

Calculate the average torque

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

Synchronous machine power-angle curve



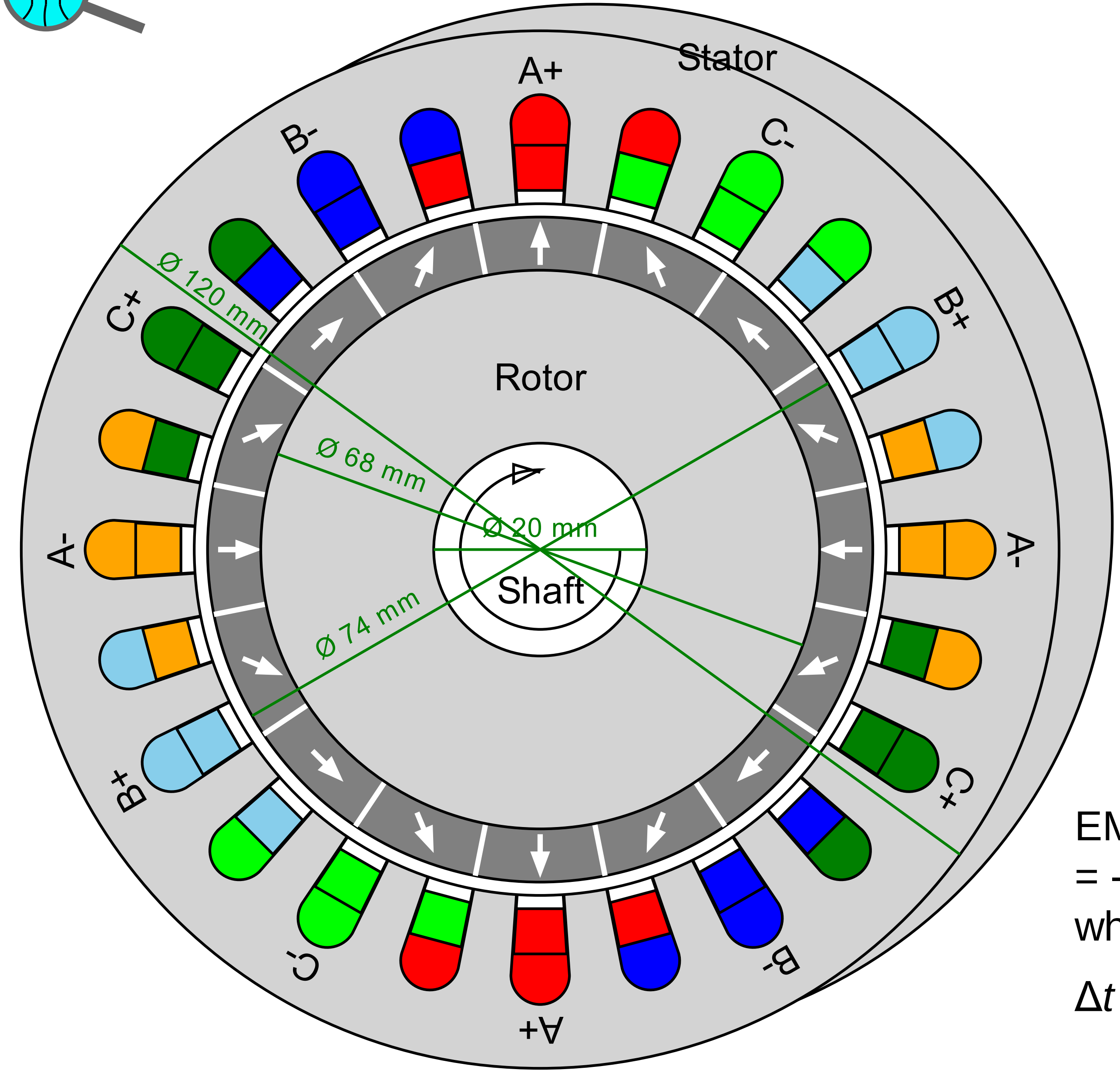
Stator winding current density		3.00E+06	A/m2		
Rotor poles pairs *p* =		2			
Rotor angle sweep from	0	to	90	with step	
Power angle	30				

Get Torque

Angle	Torque, N*m
0	2.450
0.5	2.504
1	2.562
1.5	2.611
2	2.654
2.5	2.713
3	2.751
3.5	2.773

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

Halbach array generator voltage



Problem specification:

Stator phase coil number of turns w = 90,
Permanent magnet coercive force 730 kA/m,
Rotor poles 2p = 4,
Synchronous rotation speed n = 750 rpm.

Task:

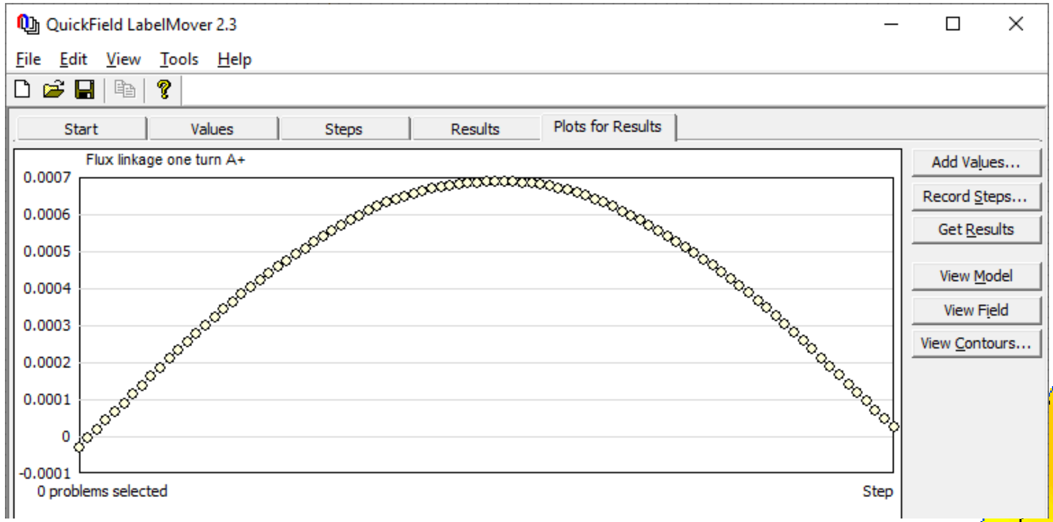
Calculate the electromotive force (EMF).

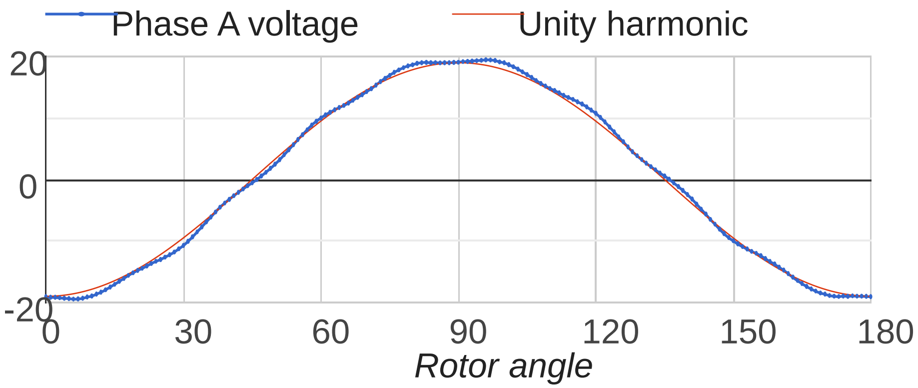
EMF = $-w * d\Phi/dt$ =
= $-w * \Delta\Phi / \Delta t$,
where

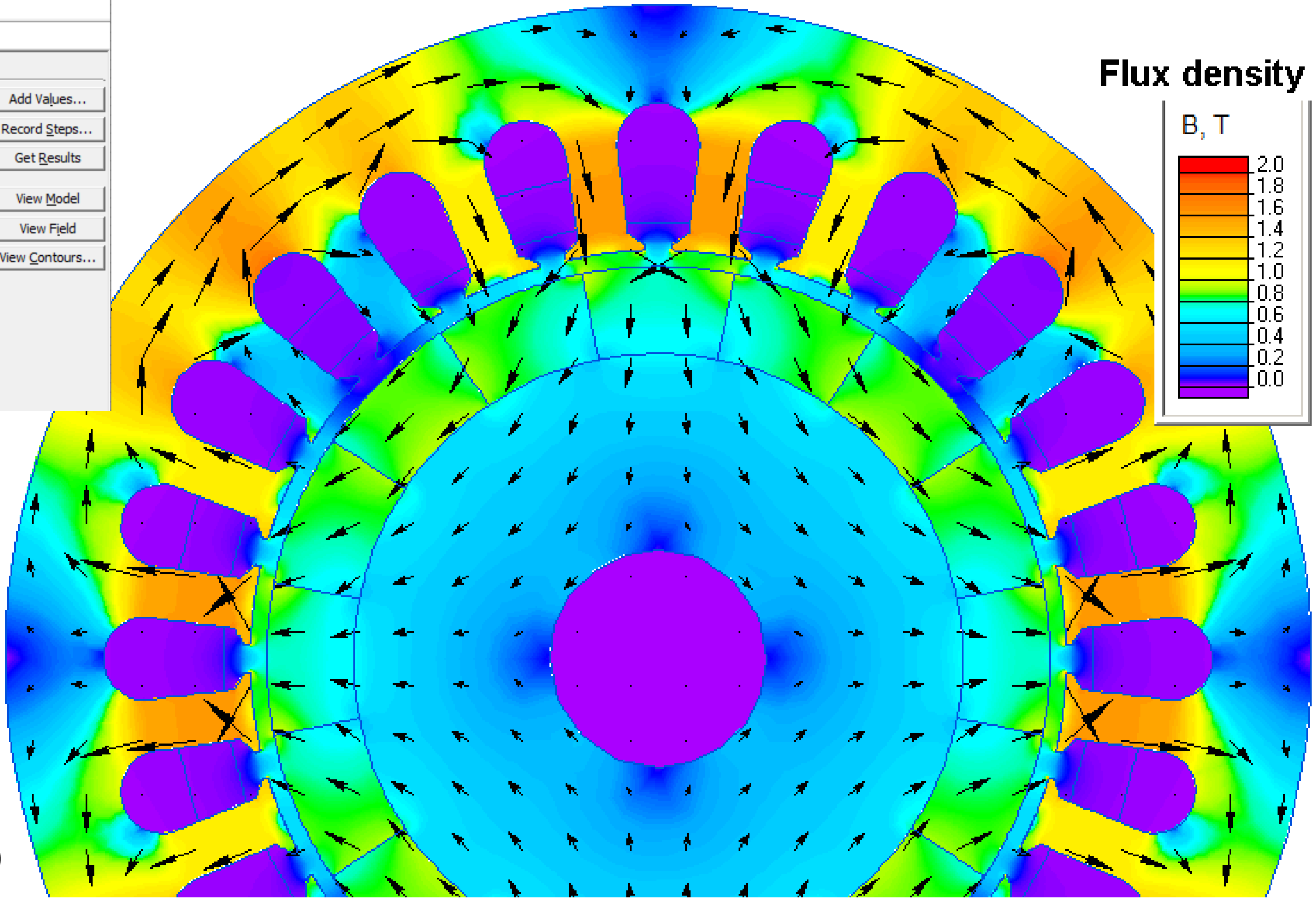
$$\Delta t = \frac{\Delta\varphi/360}{n/60}$$

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

Halbach array generator voltage

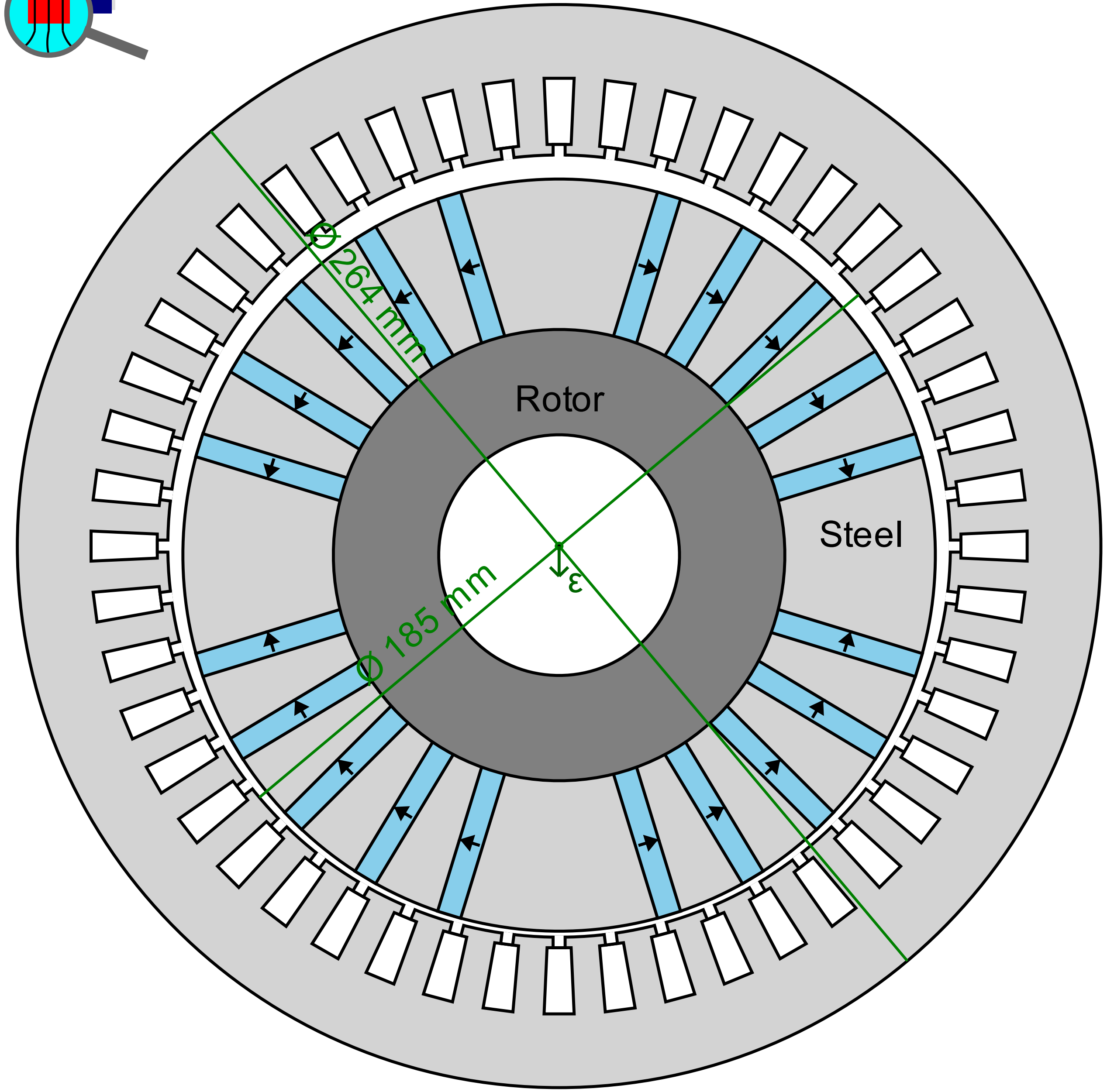






https://quickfield.com/advanced/halbach_rotor_generator.htm

Unbalanced magnetic pull



Problem specification:

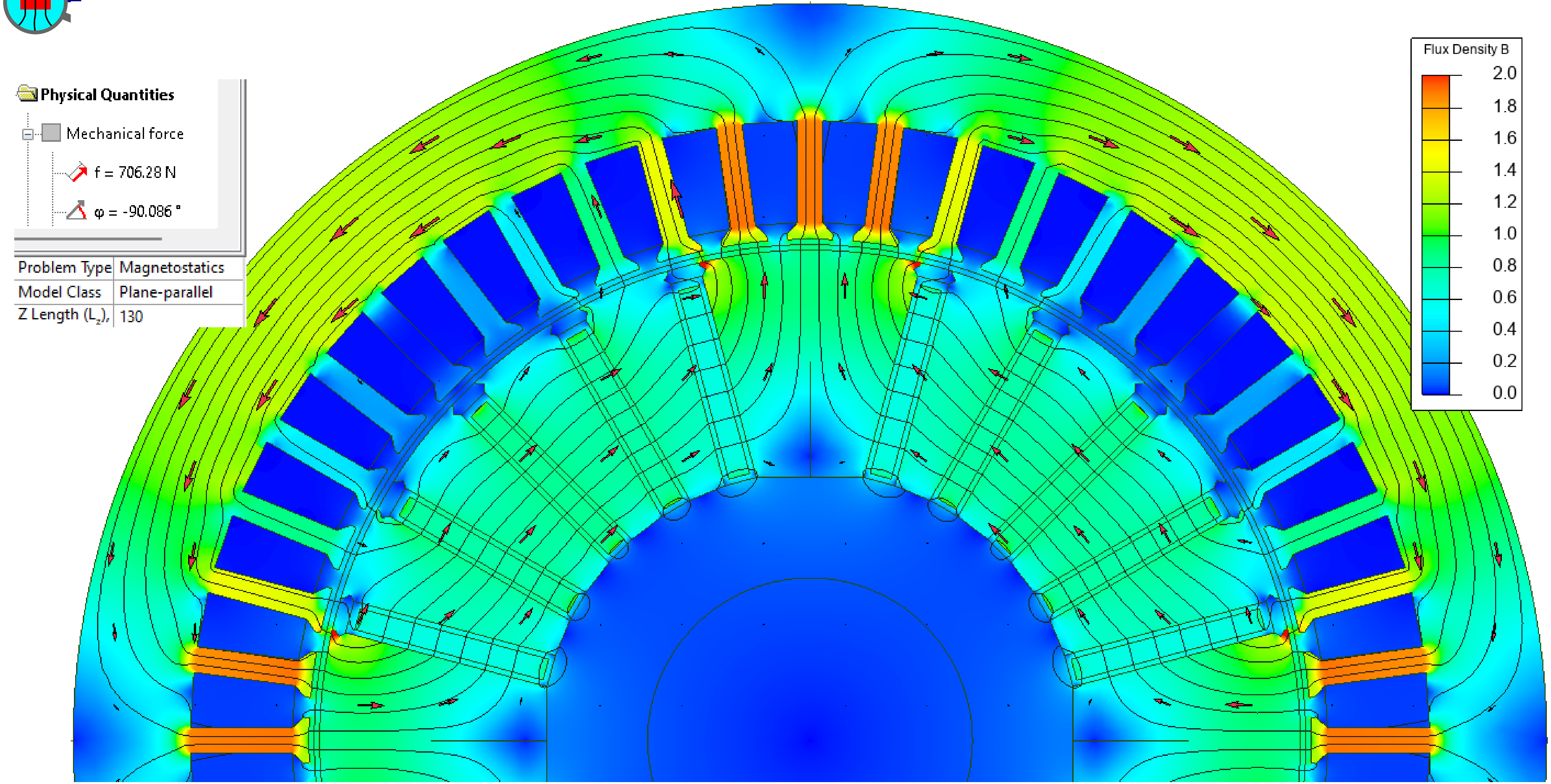
Permanent magnet coercive force 955 kA/m, relative magnetic permeability 1.2.
Air gap length 2 mm,
static eccentricity ε = 50% of the air gap length.

Task:

Calculate the force acting on the rotor.

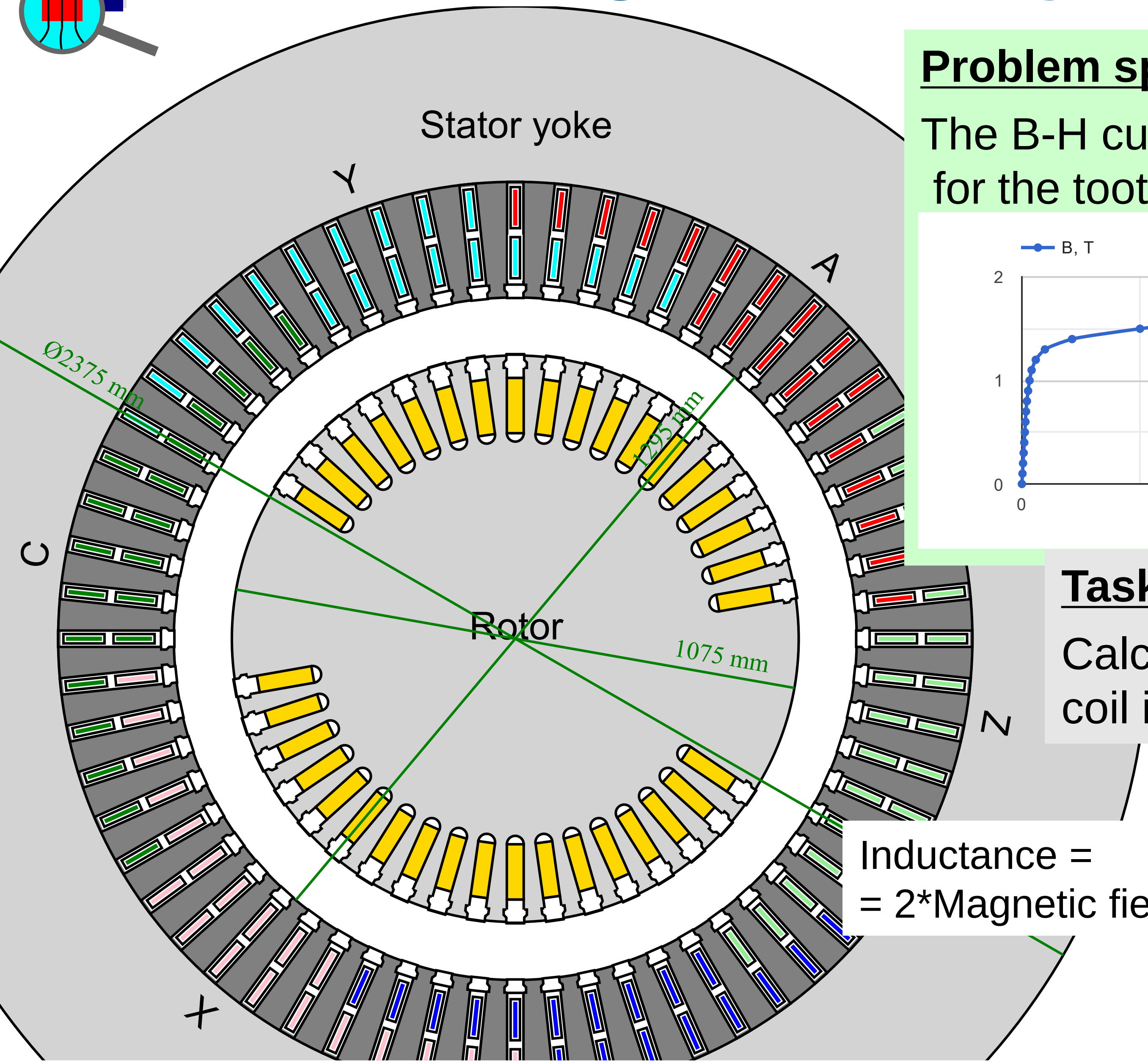
https://quickfield.com/advanced/unbalanced_magnetic_pull.htm

Unbalanced magnetic pull



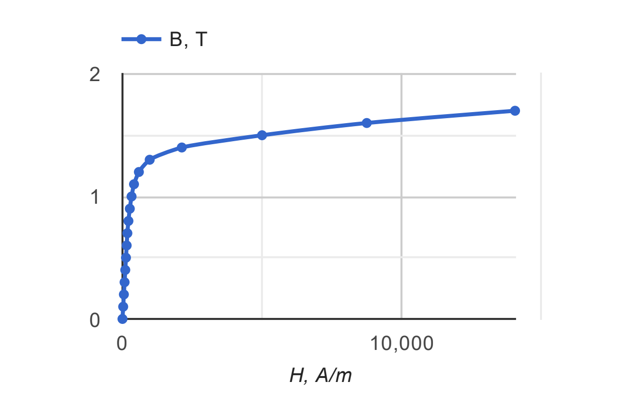
https://quickfield.com/advanced/unbalanced_magnetic_pull.htm

Turbine generator synchronous inductance

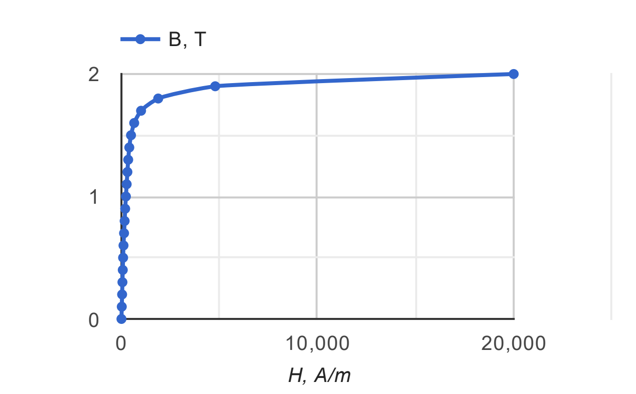


Problem specification:

The B-H curve for the tooth zone



The B-H curve for the rotor and stator yoke



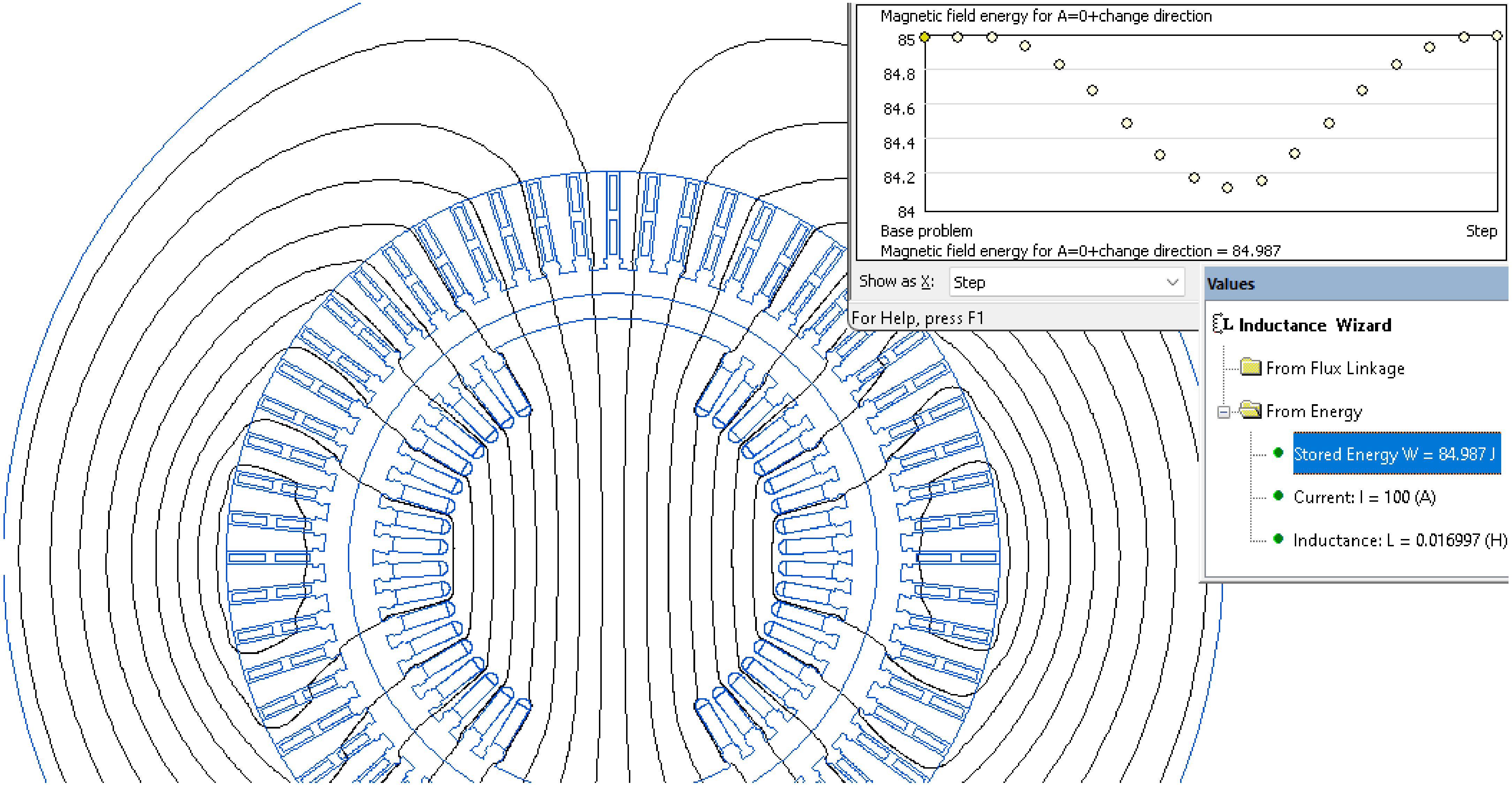
Task:

Calculate phase coil inductance.

Inductance =
= 2*Magnetic field energy / Current^2

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

Turbine generator synchronous inductance



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

This recording is over

More recordings and simulation examples at

www.quickfield.com

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