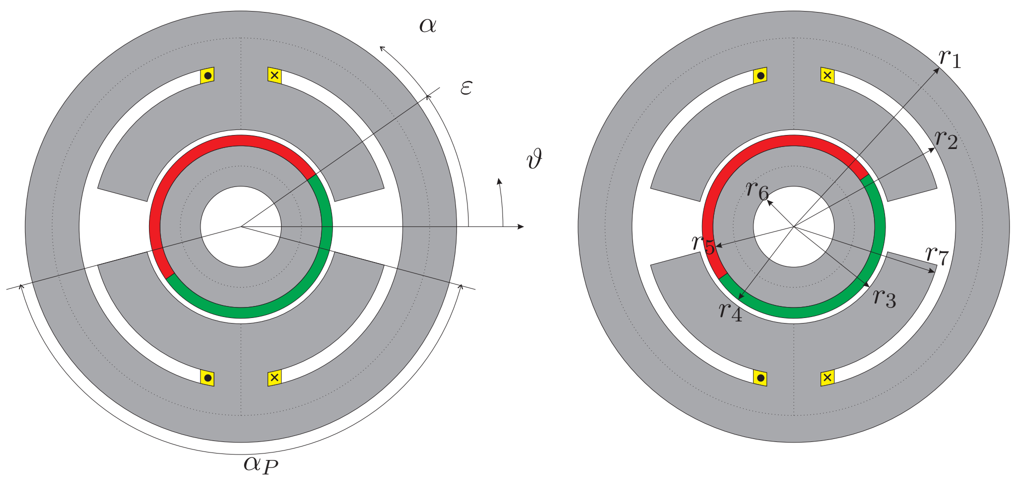
Exercise 12: Electronically Commutated DC motor

Given below is an electronically commutated DC motor (Brushless DC motor, BLDC) with two concentrated windings, which are connected in series. The number of turns of each winding is $N = 100$. The rotor has two radially magnetized NdFeB permanent magnets with a magnetization of $m = 1\,\mathrm{T}$.

The geometrical data are:

- Outer radius of the yoke $r_1 = 80\,\mathrm{mm}$
- Inner radius of the yoke $r_2 = 60\,\mathrm{mm}$
- Inner radius of the stator pole $r_3 = 36\,\mathrm{mm}$
- Outer radius of the rotor $r_4 = 34\,\mathrm{mm}$
- Outer radius of the shaft $r_5 = 30\,\mathrm{mm}$
- Inner radius of the shaft $r_6 = 15\,\mathrm{mm}$
- Outer radius of the stator pole $r_7 = 55\,\mathrm{mm}$
- Axial length $l_{\mathrm{Motor}} = 100\,\mathrm{mm}$
- Width of the connection between stator yoke and pole $r_1 - r_2$
- Polewidth $\alpha_P = \frac{2}{3}\pi$.

The stator and rotor iron can be considered as linear with a relative permeability $\mu_{r,Fe} = 4000$. The ohmic resistance of the stator windings can be neglected.



The windings are not excited.

a) Calculate the flux-density of the air gap b_L. Plot the variation of the flux-density along the rotor-fixed coordinate α.

b) Calculate the flux/pole Φ_P and the flux linkage/phase ψ_P. Plot the variation of the flux linkage/phase with respect to the rotor position ε.

c) Calculate and plot the induced phase EMFs for a rotor speed of $n = 3000\,\mathrm{min}^{-1}$ with respect to the rotor position ε.

The windings are now excited with a current of $i_0 = 10\,\mathrm{A}$.

d) Plot the variation of the phase current as a function of the rotor position ε.

e) Calculate the torque T delivered by the motor.