Magnetic Circuit with Air Gap: Reluctance, Flux and Inductance

Core and air-gap reluctance, flux, flux density, field strength and inductance of a coil on an iron core with an air gap, with optional gap fringing.

Method: Magnetic circuit analysis with reluctances in series

Input parameters

Unit system: SI

Parameter	Value	Unit
Number of turns	500.00	
Coil current	2.0000	A
Mean magnetic path length in the core	400.00	mm
Core cross-section area	9.0000	cm²
Relative permeability of the core	3,000.0	
Air gap length (0 for none)	1.0000	mm
Gap fringing	Add the gap length to each side of a square pole	

Calculated results

Parameter	Value	Unit
Magnetomotive force NI	1,000.0	A
Core reluctance	117,893	A/Wb
Gap reluctance	828,069	A/Wb
Flux	1.0571	mWb
Flux density in the core	1.1746	T
Field strength in the core	311.57	A/m
Inductance N²/ℛ	264.28	mH
Stored energy ½LI²	0.52856	J

Notes for this case

- Linear magnetic circuit: constant permeability, all flux confined to the core except the fringing at the gap. $\mu_0 = 4\pi \times 10^{-7}$ H/m.

Formula and method

$$\mathcal{R}_c = \frac{l_c}{\mu_0 \mu_r A_c}, \quad \mathcal{R}_g = \frac{l_g}{\mu_0 A_g}, \quad \Phi = \frac{NI}{\mathcal{R}_c + \mathcal{R}_g}, \quad L = \frac{N^2}{\mathcal{R}_c + \mathcal{R}_g}$$

Variables

N	Number of turns	-
I	Coil current	A
l_c	Mean magnetic path length in the core	m
A_c	Core cross-section area	m²
μ_r	Relative permeability of the core	-
l_g	Air gap length (0 for none)	m
$\mathrm{fringing}$	Gap fringing	-

$\mathcal{F}$	Magnetomotive force NI	A
$\mathcal{R}_c$	Core reluctance	A/Wb
$\mathcal{R}_g$	Gap reluctance	A/Wb
Φ	Flux	Wb
B_c	Flux density in the core	T
H_c	Field strength in the core	A/m
L	Inductance N²/ℛ	H
W	Stored energy ½LI²	J

Method and standards

Series magnetic circuit with constant permeability.

Assumptions and limits

- Linear iron, uniform flux in the core.

References

Magnetic circuit analysis with reluctances in series

Report details

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Release checks	3 reference cases of this calculator, computed independently, are checked on every release

Results are for engineering estimation. Verify critical designs against the referenced standards and your own data.

This calculator online

https://calc.firecad.com/electrical/circuits/magnetic-circuit-reluctance

Open this case on calc.firecad.com →

Reopens the calculator with the inputs of this report.