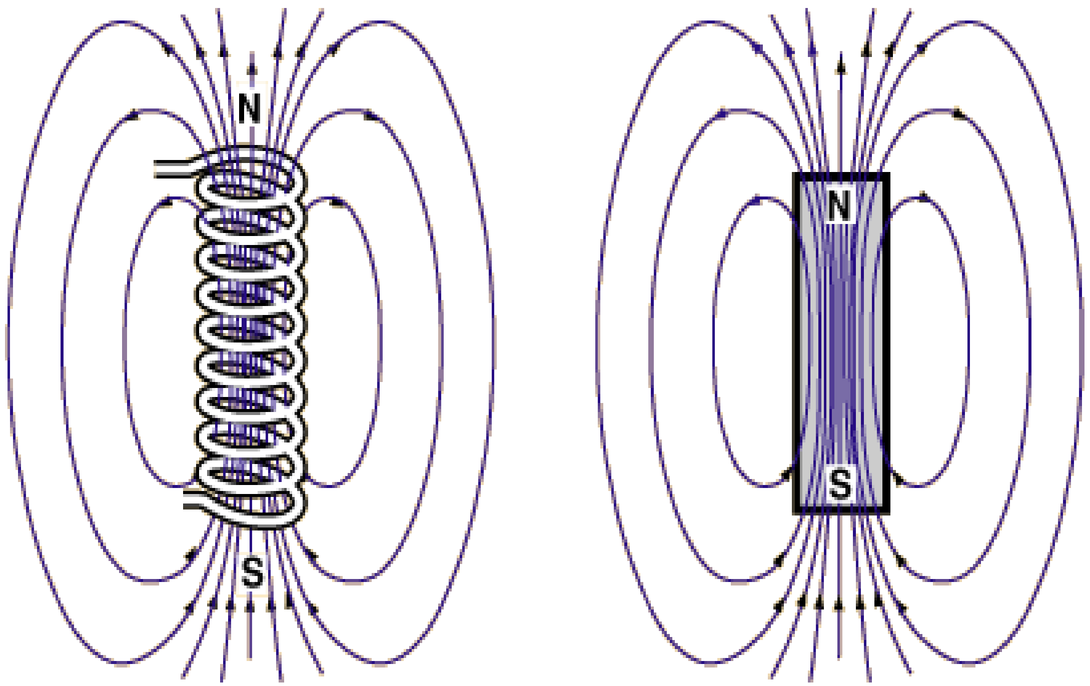
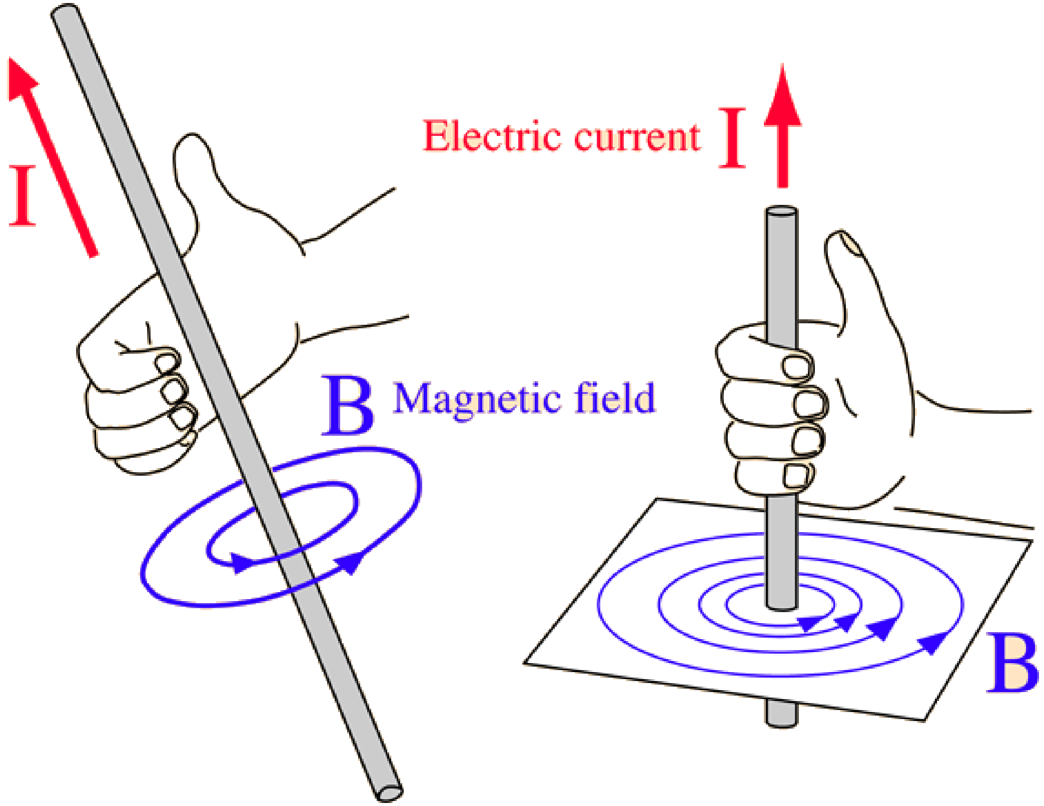
Magnetic field created by current

1. Permanent Magnet

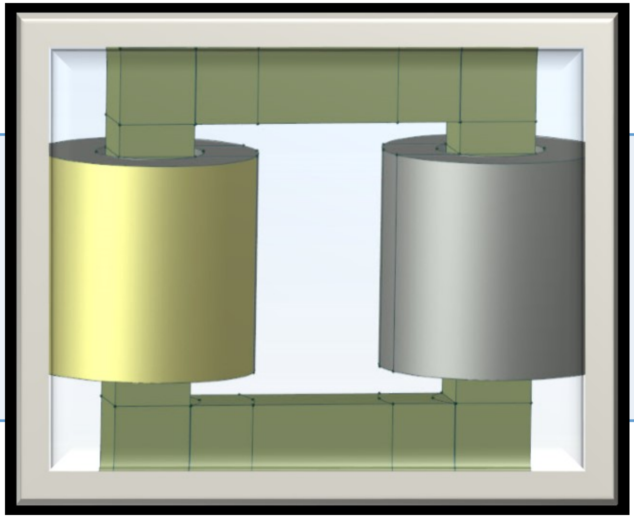


2. Current



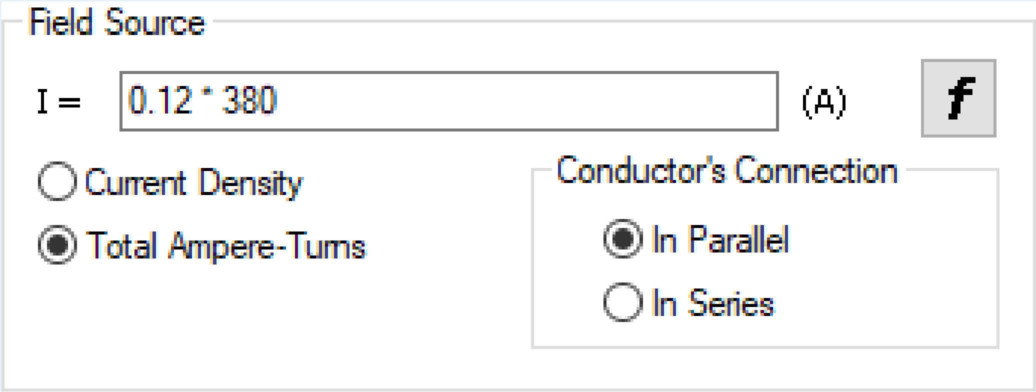
Magnetic field created by current

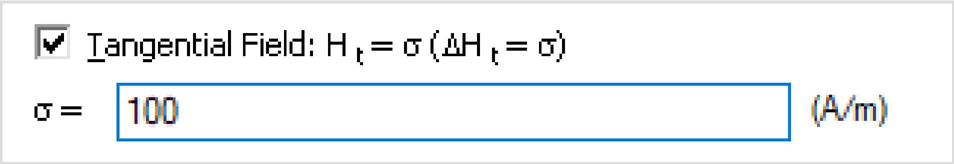
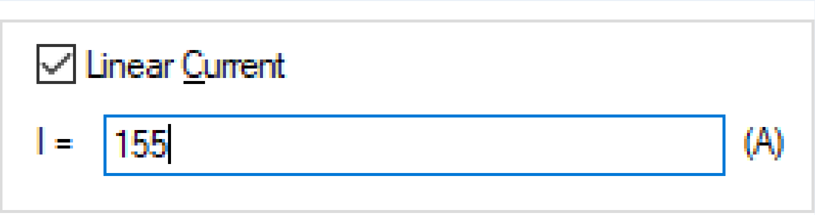
1	How to set current in QuickField: • Volume current density / total current • Surface current density (by Neumann boundary condition) • Linear current
2	Magnetostatic is about DC currents. What to do with AC devices?
3	Let's practice with the transformer: 1. Idle-run test 2. Short-circuit test
5	How to extract results: Flux linkage, Inductance, Induced EMF



Magnetic field created by current

What	Where	How

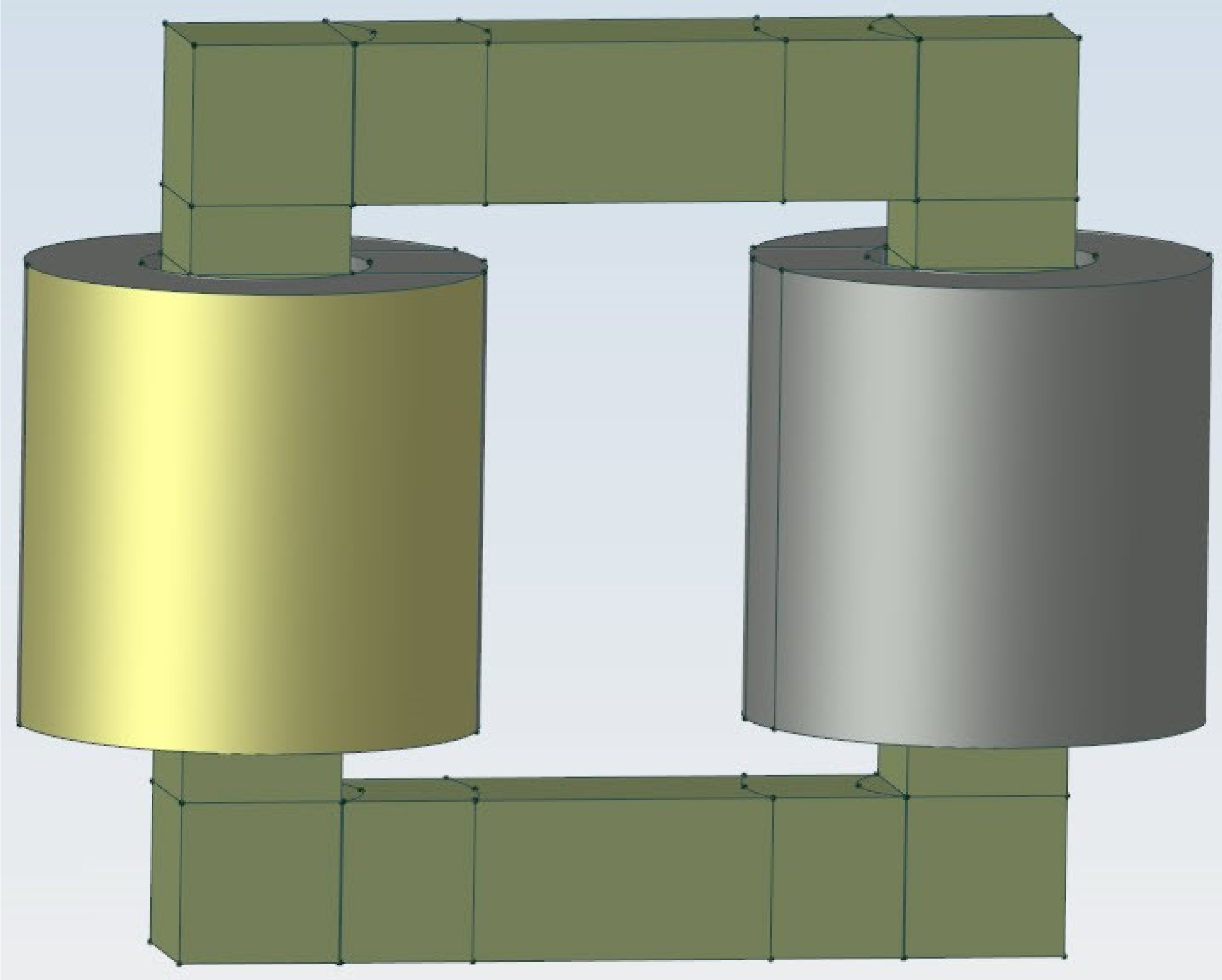
Volume current	Block	• Given current density (A/m^2)
		• Total Ampere-turns (A)
		  • Parallel / Serial
		    (for total current only)
		

Surface current	Edge	• Surface current density (A/m) (can depend on coordinates) 
Linear current	Vertex	• Given current (A) 

The simple transformer

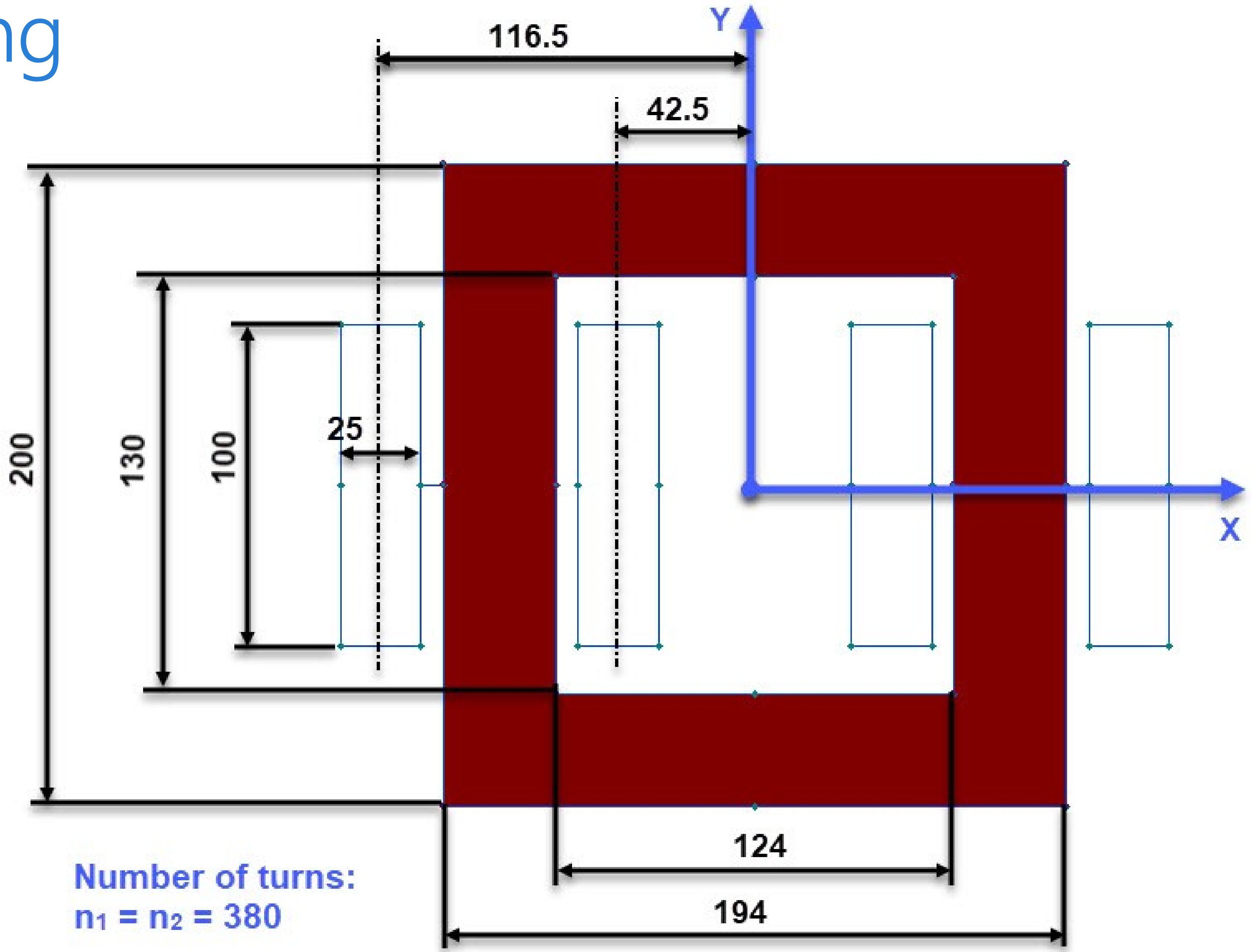
1. Photo

2. Schematic view

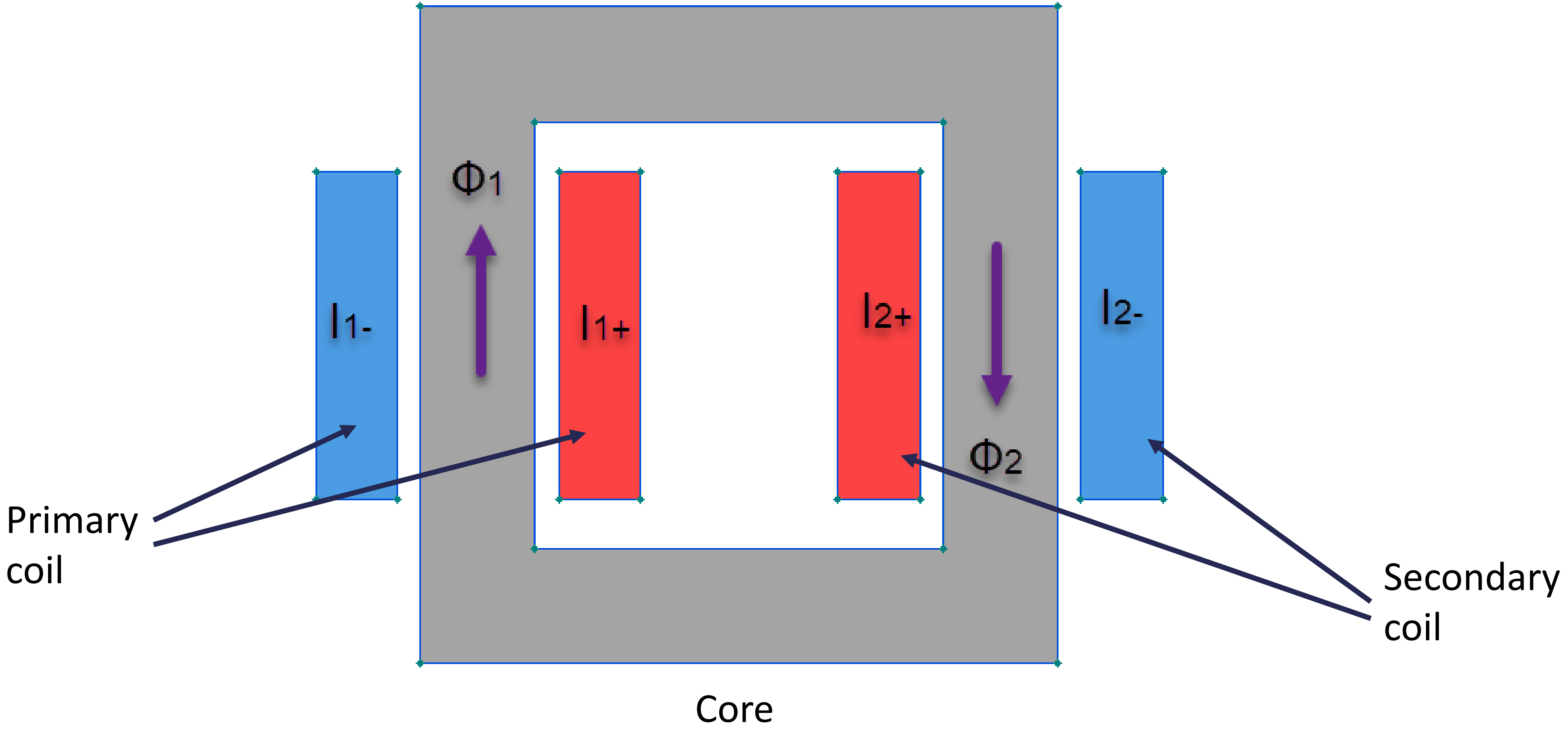


Transformer sizing

Core depth
(in Z-direction):
$L_{z=}$ 35 mm



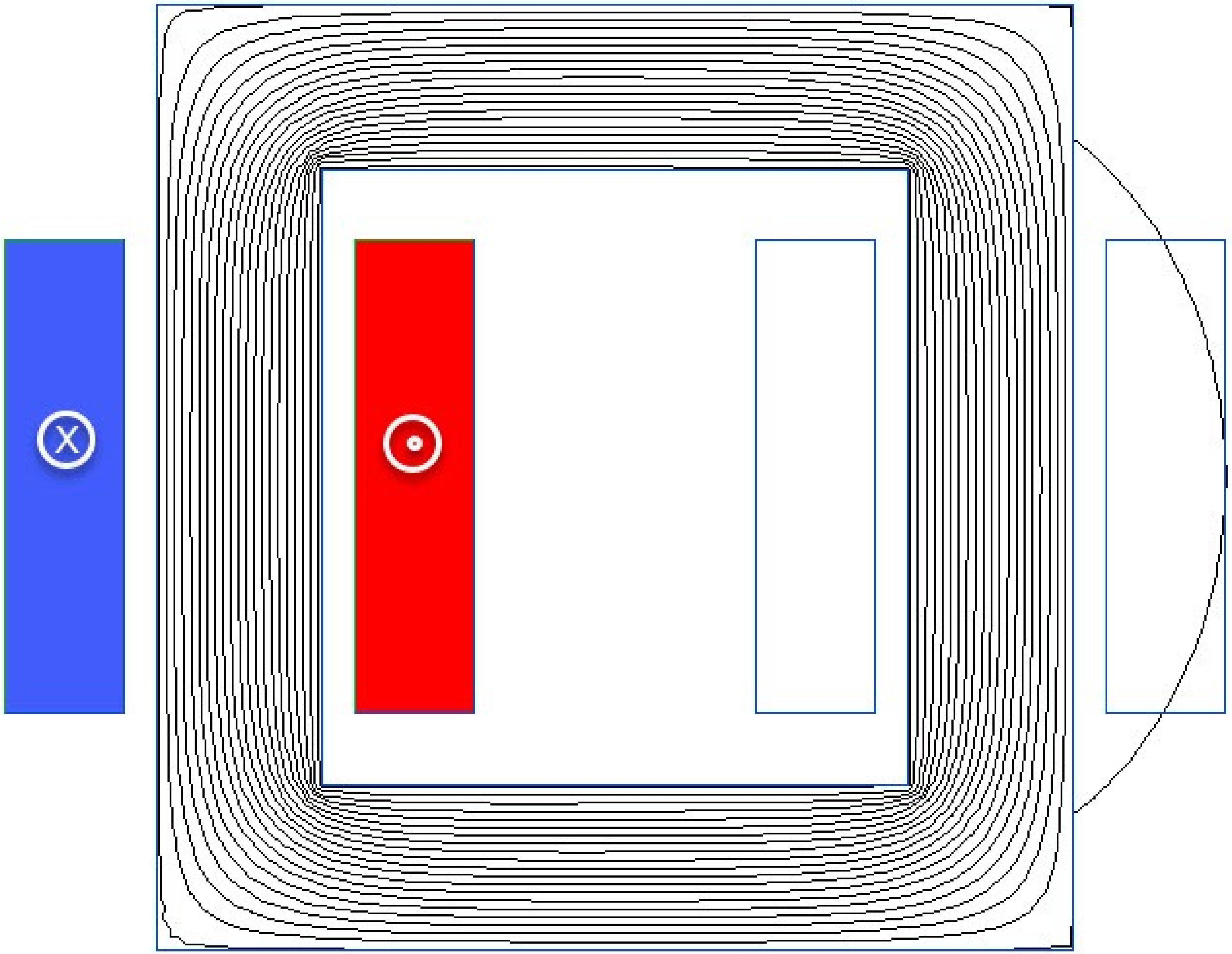
Transformer labels



No-load test:

<u>Given:</u>
The primary current I_1

<u>Calculate</u>:
The secondary voltage V_2



Calculating induced voltage:

1. By flux linkage:

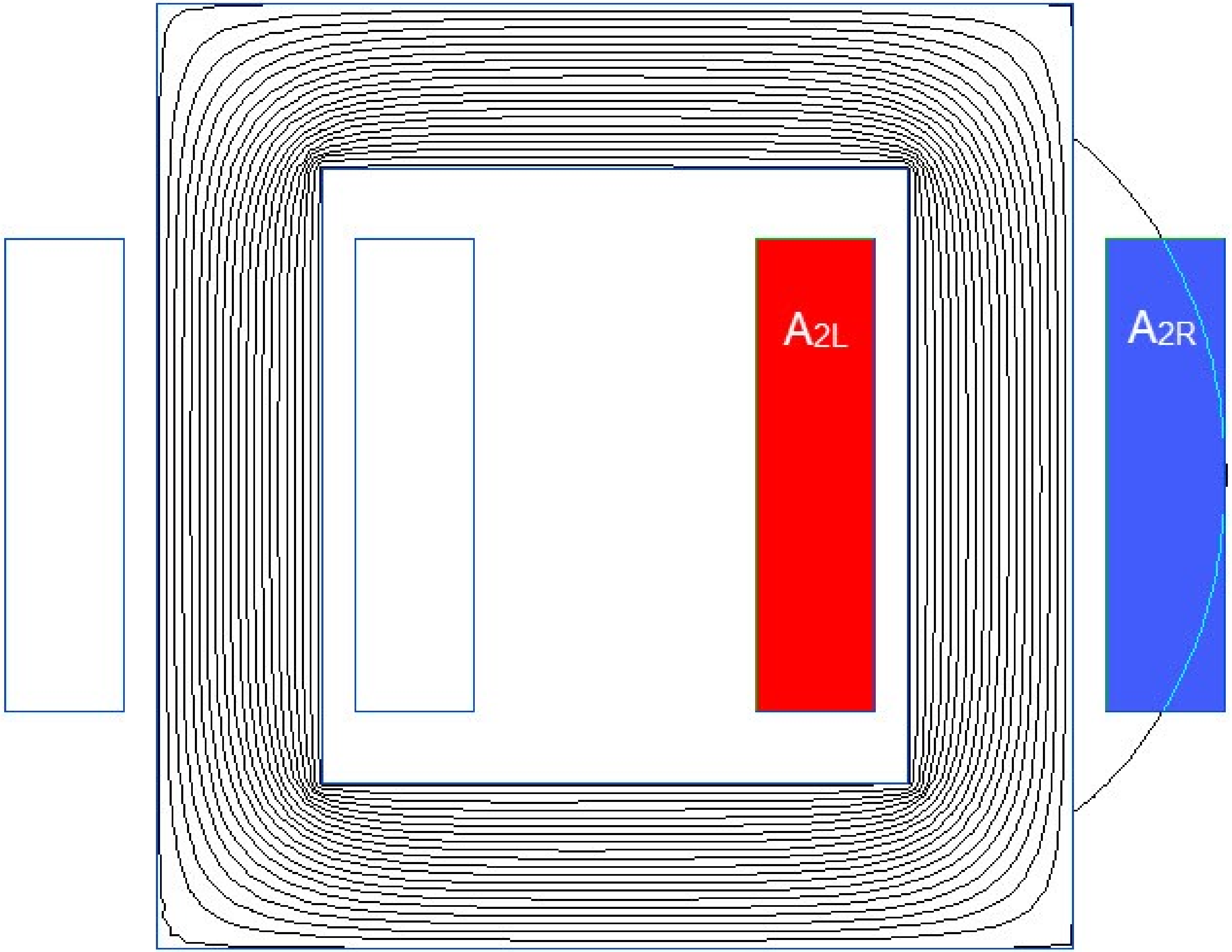
$$E = \frac{\partial \Psi}{\partial t} = \omega \Psi = \omega n(\Phi_L - \Phi_R)$$

2. By inductance:

$$E_1 = I_1 \cdot X_1 = I_1 \omega L_1$$

We can calculate inductance either

- by flux linkage $L = \Psi / I$, or
- by stored energy $L = 2W/I^2$



Calculating induced voltage:

1. By flux linkage:

$$E = \frac{\partial \Psi}{\partial t} = \omega \Psi = \omega n(\Phi_L - \Phi_R)$$

Flux Linkage	secondary		primary	
left	Φ_{2L}	-7.13E-05 Wb	Φ_{1L}	8.61E-07 Wb
right	Φ_{2R}	-3.73E-07 Wb	Φ_{1R}	-7.19E-05 Wb
	$\mathbf{E_2}$	-8.47 V	$\mathbf{E_1}$	8.69 V

2. By inductance:

$$E_1 = I_1 \cdot X_1 = I_1 \omega L_1$$

We can calculate inductance either:

- by flux linkage $L = \Psi / I$, or
- by stored energy $L = 2W/I^2$

From Flux Linkage			
Flux Linkage:	Ψ	0.03	(Wb)
Current:	I	0.12	(A)
Inductance:	L	0.23049	(H)
From Energy			
Stored Energy	W	1.66E-03	J
Current:	I	0.12	(A)
Inductance:	L	0.23035	(H)
Voltage:	E_1	8.68	V

Calculate the short-circuit impedance:

Short-circuit impedance of a pair of windings:
the voltage required to be applied at rated frequency to the terminals of a winding of a single-phase transformer, to cause the rated current to flow through these terminals when the terminals of the other winding are short-circuited.
The impedance voltage at rated current is usually expressed as a percentage of the rated voltage

Opposite connection:

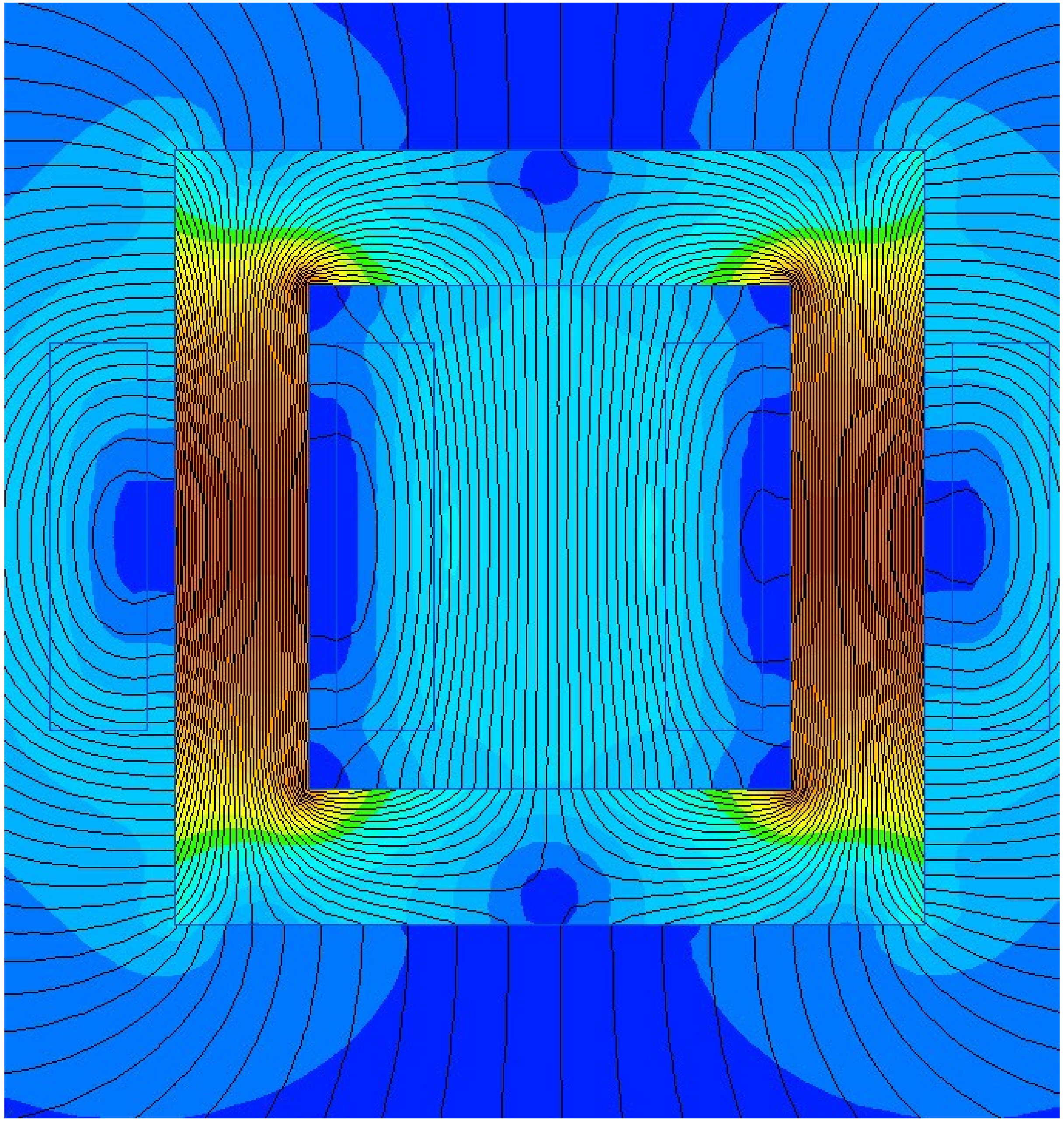
$I_1 = -I_2$

By Energy:

W	0.579269	J
I_1	10	A
$L_\sigma = 2W / I^2$	**0.0116**	H

By flux linkages:

$\Phi_{prim+} - \Phi_{prim-}$	$1.539 \cdot 10^{-4}$	Wb
$\Phi_{sec+} - \Phi_{sec-}$	$-1.539 \cdot 10^{-4}$	Wb
Φ	$3.078 \cdot 10^{-4}$	Wb
$\Psi = n\Phi$	$1.17 \cdot 10^{-1}$	Wb
$L = \Psi / I$	**0.0117**	H



Flux linkage with coils

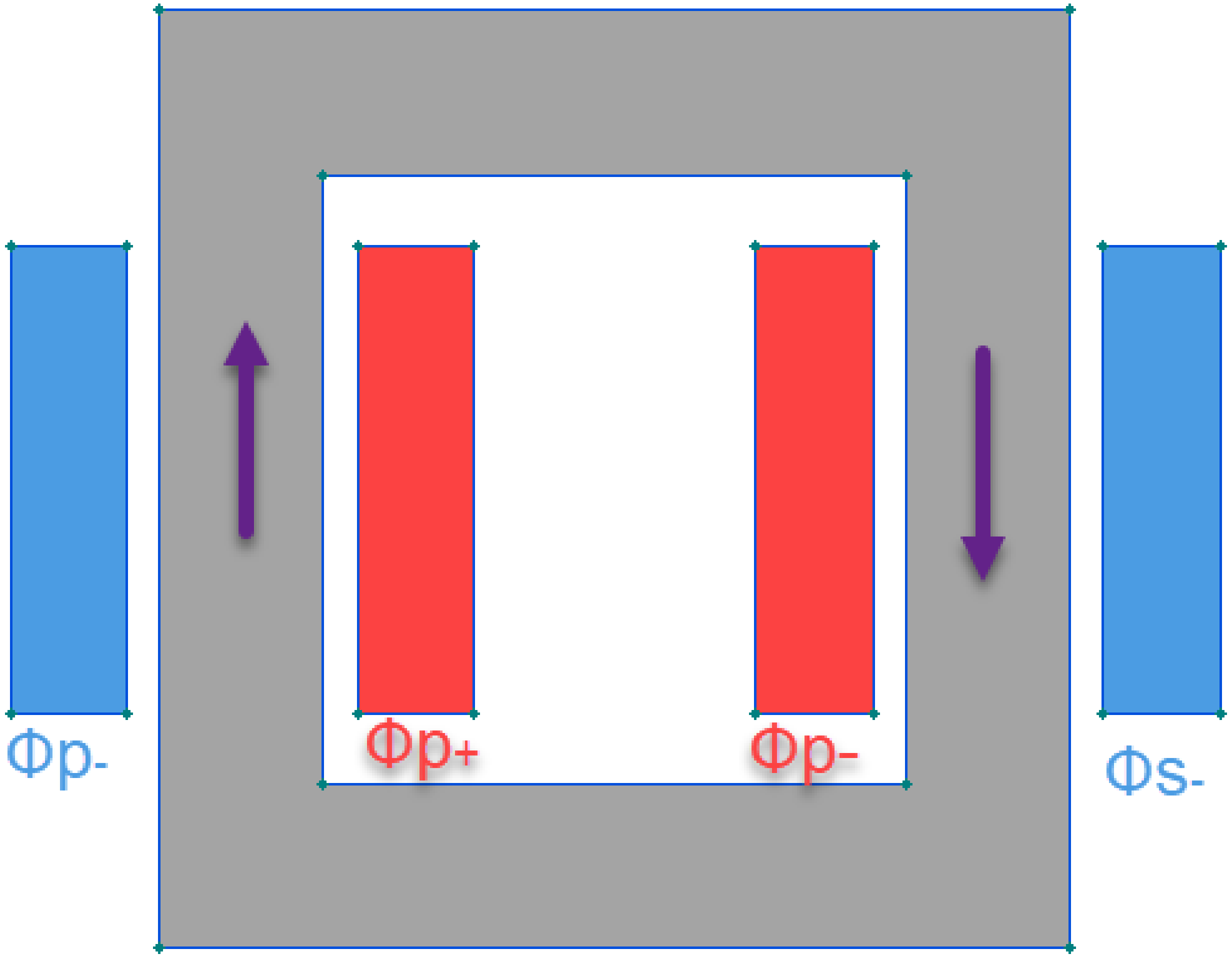
$$I_1 = -I_2$$

By Energy:

W	0.579269	J
I_1	10	A
$L_\sigma = 2W / I^2$	**0.0116**	H

By flux linkages:

$\Phi_{prim+} - \Phi_{prim-}$	$1.539 \cdot 10^{-4}$	Wb
$\Phi_{sec+} - \Phi_{sec-}$	$-1.539 \cdot 10^{-4}$	Wb
Φ	$3.078 \cdot 10^{-4}$	Wb
$\Psi = n\Phi$	$1.17 \cdot 10^{-1}$	Wb
$L = \Psi / I$	**0.0117**	H



Φprim=Φp+ - Φp-   Φsec=Φs+ - Φs-