Inductive proximity sensor

3D Application Note Summary ***(Qualified with Delaunay mesher and User memory mode)***

This application note presents the modeling of an inductive proximity sensor with Flux 3D. The same example is available in 2D.

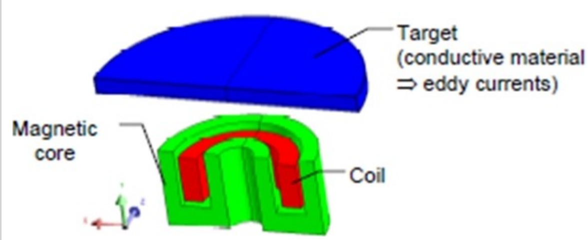
Applications	Flux main functions	Post-processed quantities
• Steady State AC Magnetic	• Symmetry • Import Flux object • Circuit coupling	• Magnetic quantities • Circuit quantities

Studied device

The studied device, represented in the figure below, is an inductive proximity sensor (contactless detection of conductive objects).

It includes the following elements: a magnetic core and a winding. This assembly creates a magnetic field which is influenced by the presence or absence of a conductive target (eddy currents).

This device operates at a frequency of 130 kHz. The coil consists of 348 elementary strands in copper. To take into account the losses in the coil due to skin effect and proximity effects, modeling is carried out in Flux through the coil conductor region with losses and detailed geometrical description.



In practice

Open example = **Open Flux** + **Run a pyFlux command file**

- Recommended memory configuration: 8000 MiB Numerical + 128 MiB Character + 512 MiB GUI
- Computation time - ex 1: t = 20’ [64 bit-16 GB RAM - 2.2 GHz]
- Computation time - ex 2: t = 2h20’ [64 bit-16 GB RAM - 2.2 GHz]

Example 1: Comparative study 2D/3D

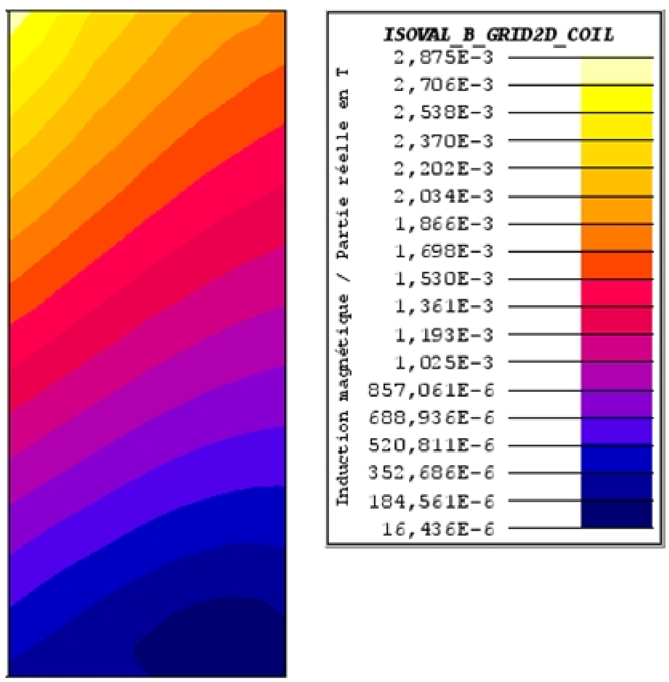
The first case is a comparative study 2D / 3D in the following operating conditions: frequency = 50 kHz, distance target - sensor = 3.5 mm.

- 2D project: core and target materials = non linear models
- 3D project: core and target materials = linear models (because ferromagnetic parts are not saturated)

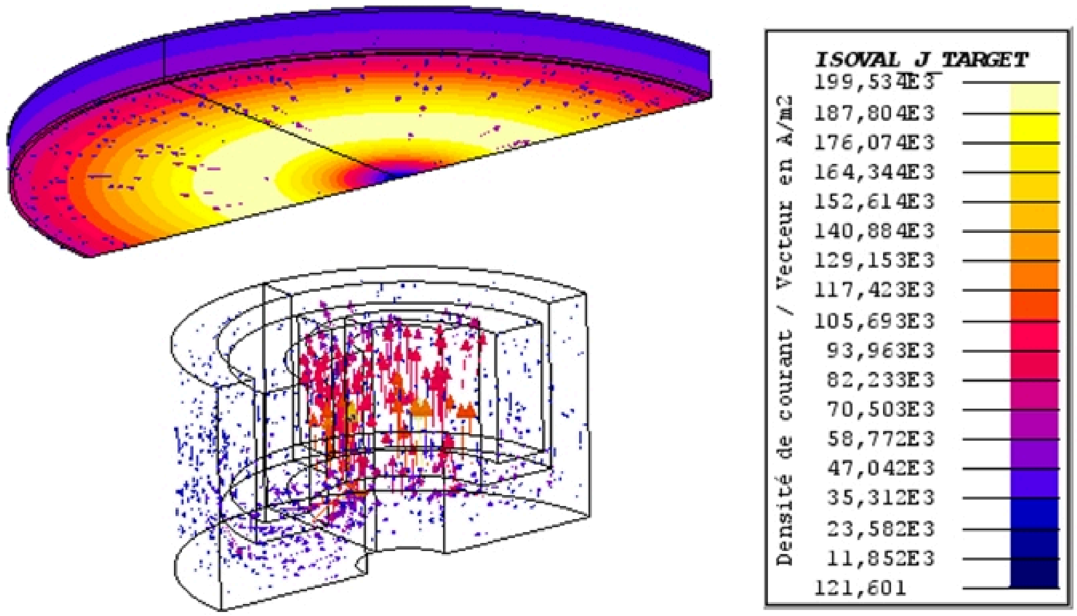
(The 2D example is accessible from the supervisor in the context **Open example**: choose the application note "Inductive proximity sensor / homogenized coil: region with losses".)

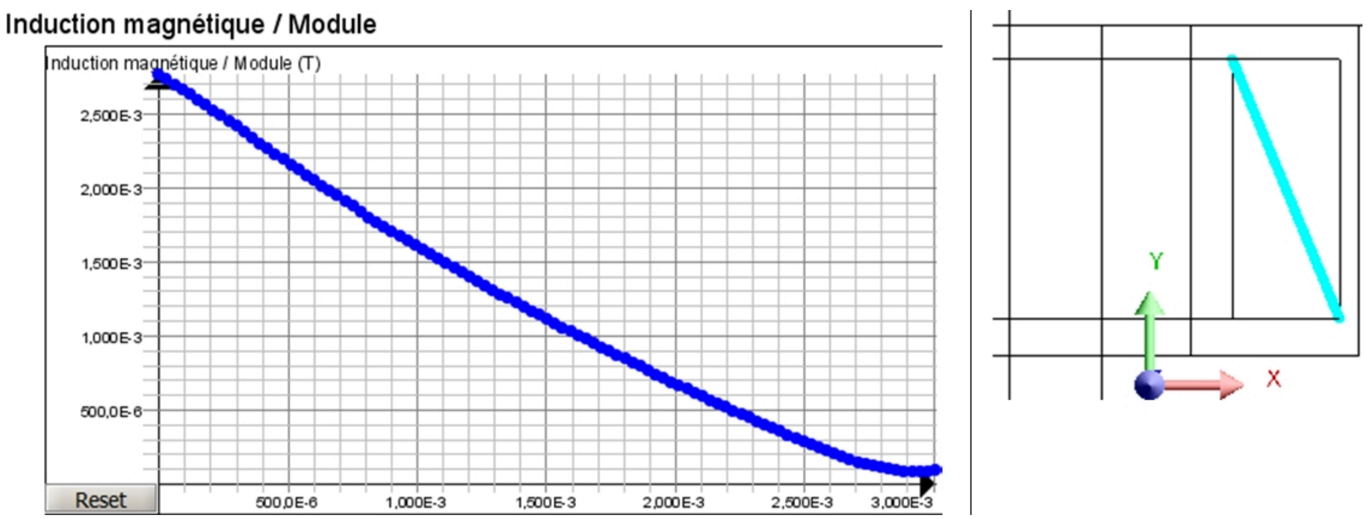
- Display isovalues of the magnetic flux density in the coil (grid 2D)
- Plot the magnetic flux density in the coil / on a diagonal path
- Compute the power in the coil (active power and reactive power)

Isovalues of the magnetic flux density in the coil:



Isovalues of the current density in the target + Arrows of the magnetic flux density:





	2D	3D
Apparent power [VA]	$12.44\ 10^{-3}$	$2 * 6.23\ 10^{-3} = 12,46\ 10^{-3}$
Active power P [W] : Real(dPowV)	$0.97\ 10^{-3}$	$2 * 0.48\ 10^{-3} = 0.96\ 10^{-3}$
Reactive power Q [VAr] : Imag(dPowV)	$12.40\ 10^{-3}$	$2 * 6.21\ 10^{-3} = 12,42\ 10^{-3}$

Example 2: Response of the sensor as a function of the distance (sensor sensitivity)

The sensor is studied at a frequency of 130 kHz.

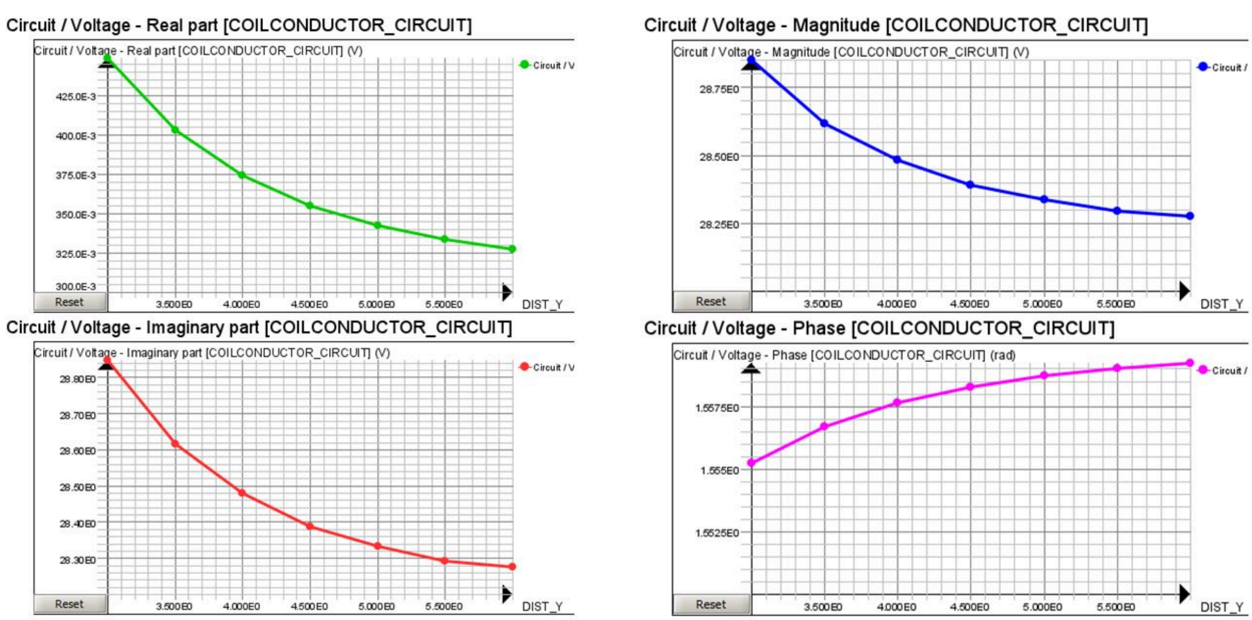
This frequency is the optimum for the studied structure (size and characteristics of the core, size of the coil and diameter of the strands in copper, ...).

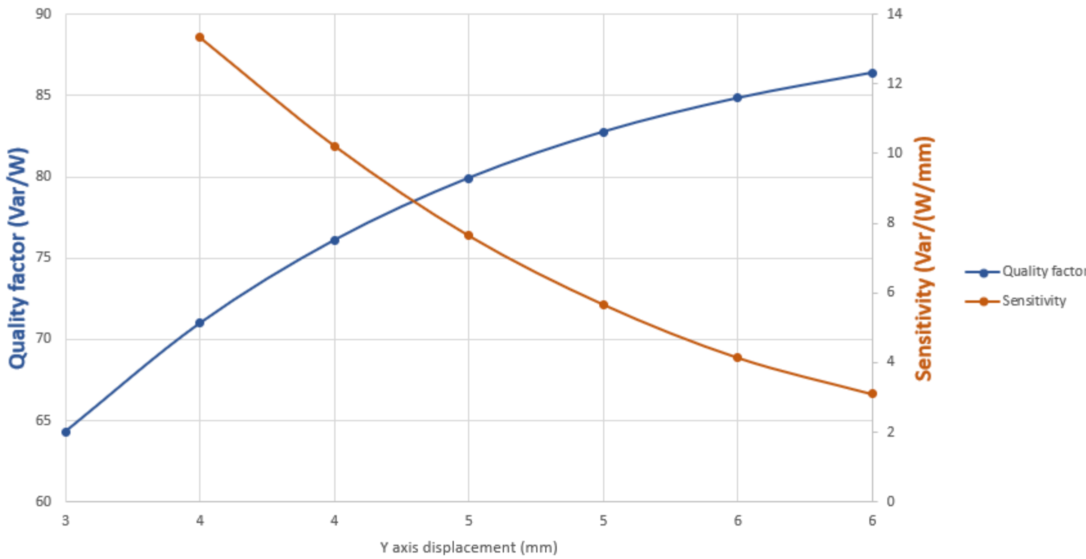
The detection method is based on the variation of the quality factor, ie the variation of the reactance / resistance ratio (Þ FQ = X/R = Lω/R). The quality

factor is calculated in Flux using the following formula:

FQ = Imag (U (CURRENT_SOURCE_1)) / Real (U (CURRENT_SOURCE_1)). The derivative of the quality factor with respect to the distance, gives the sensor sensitivity.

- 2D curve of the voltage across the coil (or the current source) as a function of the distance target - sensor [3-6 mm]
- Quality factor and sensitivity according to the position of the target




90
85
80
75
70
65
60
Quality factor (Var/W)
14
12
10
8
6
4
2
0
Sensitivity (Var/(W/mm)
3
4
4
5
5
6
6
Y axis displacement (mm)
Quality factor
Sensitivity