CEDRAT
design solutions for electrical engineering

SENSORS ANALYSIS AND DESIGN

Electromagnetic sensors

Flux, our FEM software for electromagnetic and thermal devices and systems, is the ultimate tool to design and analyse any type of electromagnetic sensors. Thanks to our optimizer ***GOT-It*** coupled with our tools, optimization of the sensor is made easy.

Using the co-simulation link between ***Flux 2D/3D*** and Portunus or SIMULINK, ***Flux*** user may easily include the accurate Finite Element model of the sensor into a system simulation to simulate a complete sensing system.

Flux features many tools to speed up the simulation and get the most accurate results, for both electromagnetic and thermal computations:

» **Geometry building facilities** such as 2D sketcher, import of CAD files (STEP, IGES, DXF, SAT, CATIAV4, CATIAV5, Pro-E…) or model reduction thanks to symmetries and periodicities

» **Meshing facilities** such as aided mesh allowing to quickly and easily mesh the finite element domain

» **Tools for easy definition of the physics:** material database (magnet, steel), non meshed coil in 3D, eddy currents in 2D and 3D.

» **Advanced embedded electrical circuit editor** including switches, inductors, capacitors, coil and solid conductor components to take into account the load and the drive of the device.

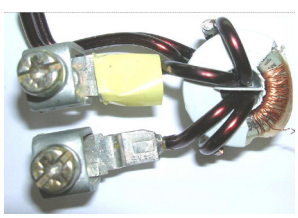
» **Electromechanical coupling** in 2D and 3D to take into account the motion of the device during the computation (mass, friction, drag force, spring stiffness…) as well as to compute all mechanical quantities (speed, position, force…).

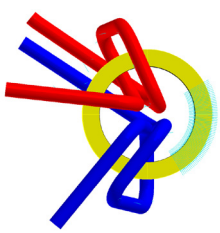
The different simulation methods (steady state multi-position computation, constant speed or transient response) make ***Flux*** a powerful tool to study any configuration of the device.

Example of sensors

» **Current sensor**

Current sensor allows measuring current in a conductor. This type of sensor is widely used to control the proper working of electrical device by detecting fault such as short circuit.





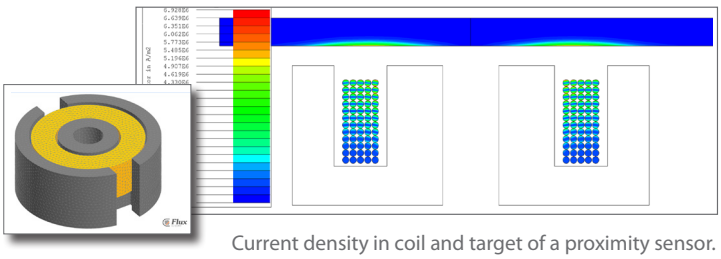
Need tools to design sensors?

CEDRAT's software suite is the answer to your need. Magnetic sensors are used in a wide range of applications in all the domains as industry, transportation and building. The role of the sensor is often crucial for the proper functioning of the device or for the security of people e.g. Antilock Braking Systems sensor, camshaft sensor or machine tool sensor. For each application, sensor has to respect a precise specification, as detection range, error on the measure, condition of functioning (range of temperature), etc... Finite Element Method matches ultimately the needs for analysing, designing and optimizing magnetic sensors, allowing doing accurate virtual prototyping to avoid the number of mockups.

Current sensors are also important components to control rotating machine allowing providing information on the current to the controller.
Non meshed coil, circuit coupling, and coupling with system simulation software, here are lot of tools offered by CEDRAT software to accurately design and analyse current sensor.

» **Position & proximity sensor**

Inductive proximity sensor is the most common sensor used for contactless detection. There are used in all the domains (industry, automotive, building). The challenge in the design of inductive sensors is to find the configuration of coil, magnet, and magnetic core allowing detecting the target at the expected distance and in expected conditions.



3D geometry of a ferrite pot core.

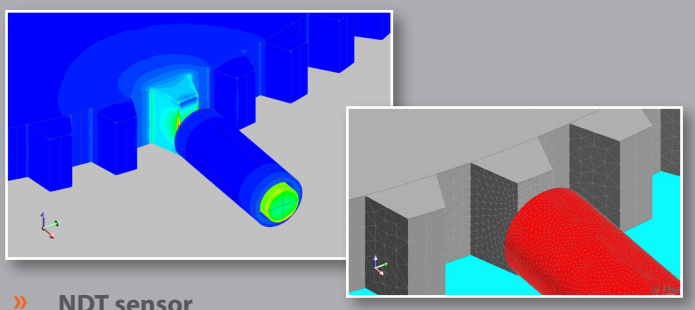
Current density in coil and target of a proximity sensor.

The electromechanical coupling and the multi-parametric features of ***Flux*** make easy to compute variation of electrical quantities due to the displacement of the target.

Both reluctance & eddy current sensor can be simulated in ***Flux 2D/3D*** since they take eddy current into account in conducting part.

» Speed sensor

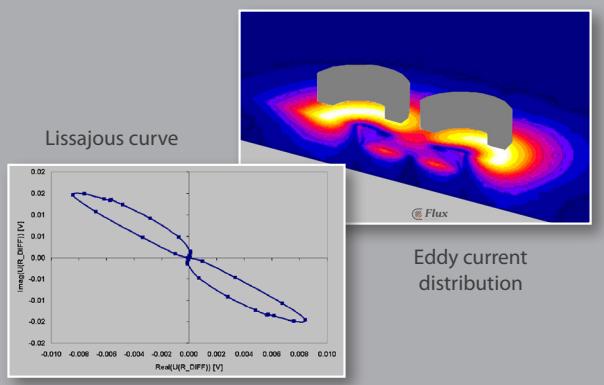
Used in lot of applications requiring the measure of speed, speed sensors consist in a magnet surround by a coil and a toothed wheel. The variation of reluctance due to the rotation of the wheel creates a variable voltage across the coil. Speed is deduced from the measure of the voltage frequency. The challenge for the speed sensor device is to find the configuration wheel, sensor, distance of the sensor, allowing to compute the speed in the expected range of speed. Thanks to the electromechanical coupling available in ***Flux 2D /3D***, the movement of the mobile part translation or rotation can be easily taken into account to simulate speed sensor. The voltage across the coil is easily computed thanks to the circuit coupling. The voltage can be injected in our system simulation software Portunus to test electronic parts of the speed sensor.



» NDT sensor

The ***Flux*** software allows representing many configurations of NDT sensor without real limits in the shape, position, orientation or in the number of flaws and sensors.
The description of the geometry and mesh will have a great influence on the accuracy of the results. In its standard range of tools, ***Flux*** offers many facilities for a proper design:

- Anisotropic mesh generators to perfectly take into account the physical phenomena such as skin effect,
- Propagation (copy paste) of geometry and mesh keeping parameter dependencies (e.g. for differential probes coils),
- Probe motion defined with partial remeshing technique for mesh noise reducing, allowing a better accuracy.



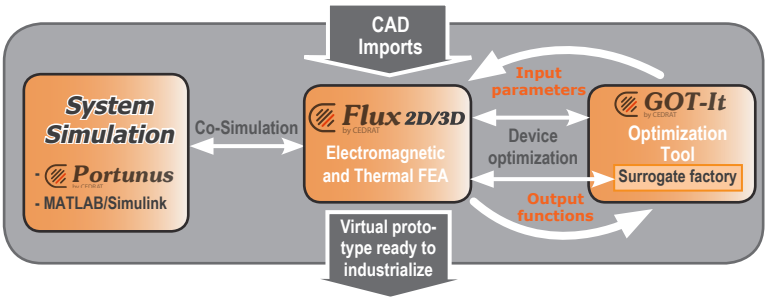
Results

Flux multiparametric postprocessor allows to get various results (flux density distribution, currents, voltages, inductance, speed, position…) in multiple formats (colour shaded maps, 2D/3D curves, isovalues display, AVI animations…).

Performance optimization

The multiparametric solver of ***Flux*** is the ultimate feature to run complete and efficient simulation. It enables the user to compute as many configurations as wished in only one shot by variation of any parameter (geometry, electrical circuit, material…). It enables the user to find performance optima as function of every cases's parameter.

To improve search of the optima, ***GOT-It*** our optimizer allows performing quickly and efficiently optimizations with several objectives and constraints. It is possible for instance to optimize the transformer performances and minimize the cost by respecting several constraints (saturation, max current, size…). Coupled to ***Flux***, ***GOT-It*** handles automatically optimizations based on 2D and 3D finite elements models.
Thanks to the indirect optimization strategy the computation time is reduced to the minimum with the guaranty of accurate results.



References

For any type of sensor, CEDRAT solutions are the reference in many organisations worldwide, such as:

ABB, Areva, CEA, Contrinex, Crouzet Automatismes, European Synchrotron Radiation Facility, Hager, Kollmorgen, L'Electricfil Industrie, LEM, Magneti Marelli, Moving Magnet Technology, Microspire, Omron, Sagem, Schneider Electric, Visteon automotive systems ...

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