DESIGN SOLUTIONS FOR ELECTRIC MOTORS

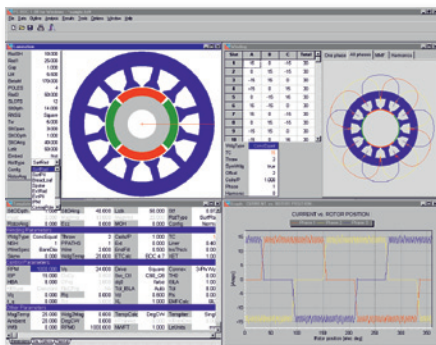## [1] MOTOR DESIGN AND ANALYSIS

» Electromagnetic analysis

SPEED: *a fast and easy to use analytical software for sizing and analysing electric machines and their drive.*

- Complete library of components (types of motors, stators and rotors, slots and bars, windings, scheme, drive…)
- Complete set of templates to design **induction, brushless permanent magnet, DC commutator, switched reluctance, wound field commutator machines**
- Easy data input and output
- Comprehensive spread sheet report

SPEED interface with outline and winding editors.

Flux: *the leading 2D and 3D Finite Element package for motor design, for a finer motor analysis.*

- **Geometry building** facilities such as import of objects and copy of geometry, mesh and parameters
- **Advanced electric circuit** with dedicated components to model brushes, squirrel cage…
- **Rotating kinematic coupling** to take into account the motion of the machine **(inertia, friction, drag torque…)** as well as to compute the mechanical values **(speed, torque, position…)**
- **Skew model** enables taking into account 3D effects, avoiding full long 3D analysis thanks to 2,5D models
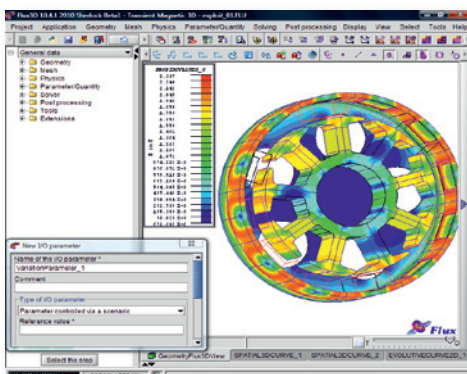
Flux density in rotor and stator of brushless motor (Flux modelling).

## *Powerful tools for powerful machines*

From watch motors to power plant generators, CEDRAT offers a full suite of tools for the design, the analysis and optimization of a wide range of rotating electric machines.
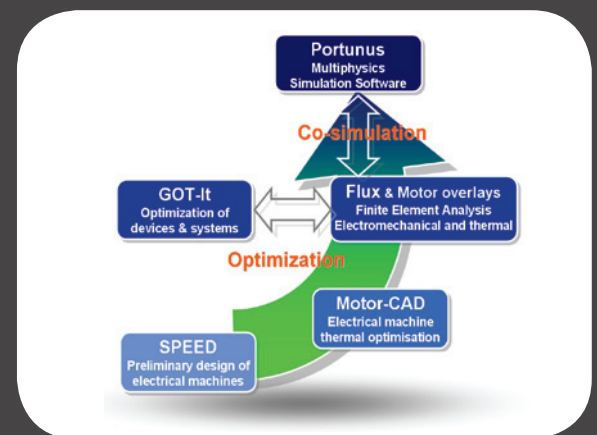
» Thermal analysis

Motor-CAD: *the most advanced motor design analytical software dedicated to simplify the complexity of 3D thermal analysis of electric machines.*

- **Numerous sophisticated cooling methods:** spiral grooves, liquid cooling, through ventilation
- Static or transient
- Comprehensive results analysis: thermal equivalent circuits, transient graphs, temperatures displayed on cross sections, comprehensive output data, sensitivity analysis, results export
- **Quick and straightforward tool** for non heat transfer specialists
- Ideal to evaluate different cooling options and for motors size reduction
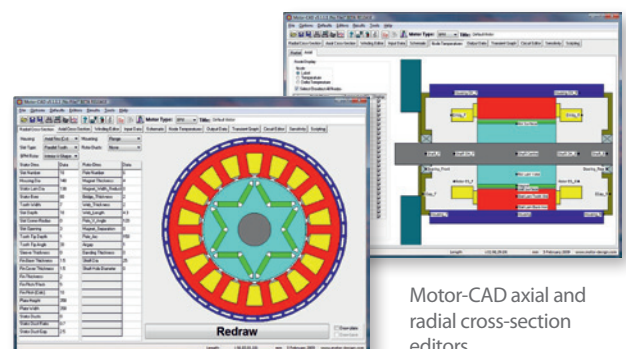
Motor-CAD axial and radial cross-section editors.
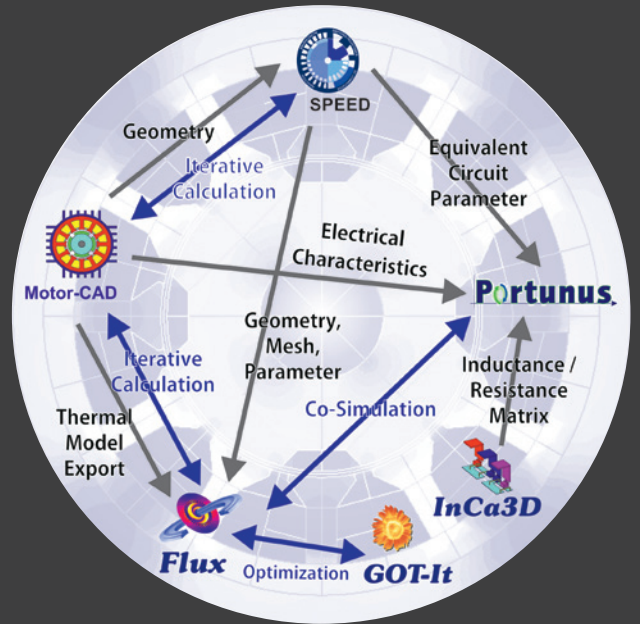
» The machine optimization

GOT-It: this powerful and reliable optimizer dedicated to CEDRAT software which will enable to boost your simulation performance. When designing a machine using numerical tools, an optimization software is often required to efficiently search the optimal solution according to the user's constraints.

It will for instance enable to minimize the losses or torque ripples of a motor.
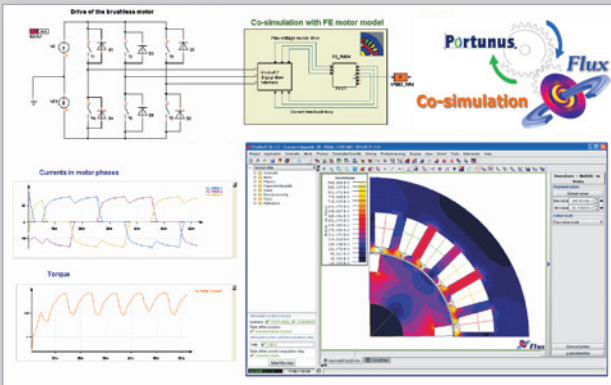
[2] THE MOTOR AND ITS DRIVE

The transient behaviour of an electric machine is widely dependent on its drive. **Modeling then both the machine and its drive gives a better prediction of the behaviour.**

The association of *Flux* (for transient electromagnetic computation) and *Portunus* (for drive and control) gave birth to the most advanced tool for system design. Thanks to its co-simulation capabilities, *Flux/Portunus* coupling enables to take into account saturation and eddy currents as well as motion and control loops within the same simulation run for 2D & 3D analysis.
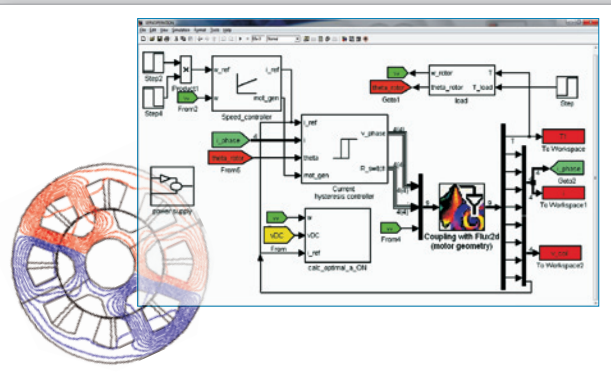

Flux / Portunus co-simulation: PMSM and its inverter at rated speed.

Another coupling between *Flux* and MATLAB/Simulink® is available.

SRD model including the drive in MATLAB/Simulink ® and the Flux finite element model with flux lines.

CEDRAT software package dedicated to motor design.

	Name	Initial	Optimum 1	Optimum 2
Motor Phase Current (Amps rms)	A_IRMS	30.00	15.40	21
Magnet Br	A_Br	0.41	0.8	0.69
Slot Opening in mm	A_SO	0.90	0.82	1.75
Stator Tooth Angle in deg.	A_SOAng	20.00	10.00	39.9
Tooth Tip Thickness in mm	A_TGD	1.00	0.80	2.00
Magnet Thickness in mm	A_LM	5.50	5.56	7.73
Magnet Arc Angle in deg.	A_BetaM	150.00	152.80	152.2
Magnet Edge Height in mm	A_Edge	5.50	5.30	4.86
Motor Losses in Watts	Losses_motor	413.42	130.67	217.31
Average Torque in N.m	T_Ave	2.51	2.50	2.5
Torque Ripples in %	T_Ripples	5.56	4.21	3.01
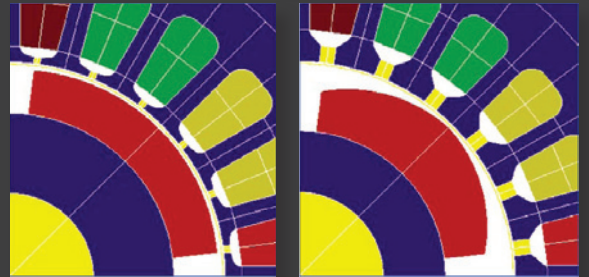
Motor optimization example using GOT-It - BPM loss minimization Base geometry - Optimized design (Optimum 2).
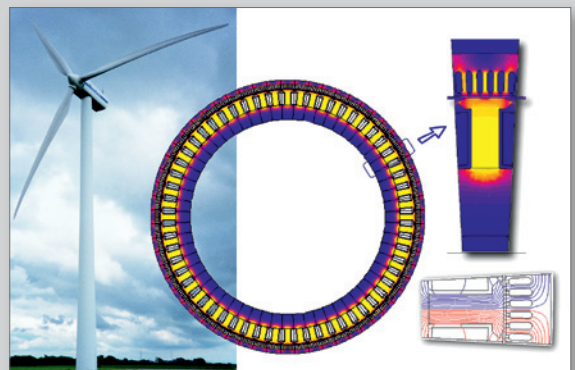
Generator for wind farm turbine modelled with Flux.

CEDRAT
design solutions for
electrical engineering

FLUX AND MOTOR OVERLAYS

The revolutionary Motor Overlays are fast, reliable and easy solutions for rotating machine design.
- **Fast**, as the designer gets rid of any tedious preprocessing and goes directly to its core job: design
- **Reliable**, as libraries of components are backed by years of engineering in motor field and implemented on users requests
- **Easy**, as *Flux* & Motor Overlays provide adapted parameters and vocabulary to the user: the designer does not need then any skills in Finite Element modelling

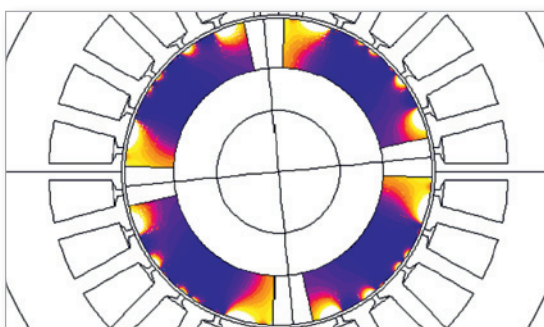### Latest paradigm for Finite Element solution

Motor Overlays benefit from latest developments in software technology provided with *Flux*. Whithin a modern GUI, *Flux* & Motor Overlays allow the user to benefit from one of the fastest solver for Finite Element simulation with natural multi-parametric capabilities to compute:
• **Back EMF**   • **Flux density in the air gap**
• **Cogging torque**   • **Iron losses**
• **Currents**   • **No load and loaded startup**
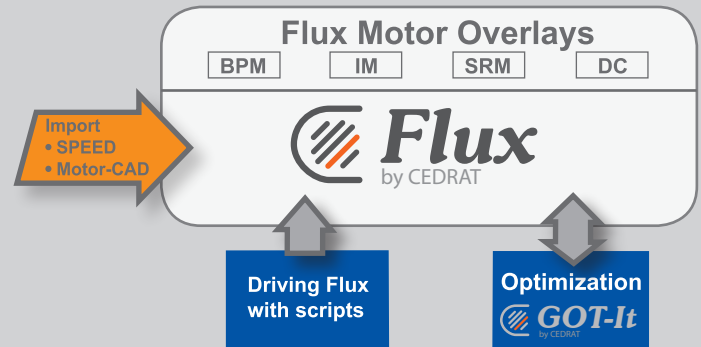• **Phase line-to-line voltages...**

Associated with *Flux* unique capabilities for motor simulation, Motor Overlays are the new generation simulation solutions for electric machines.
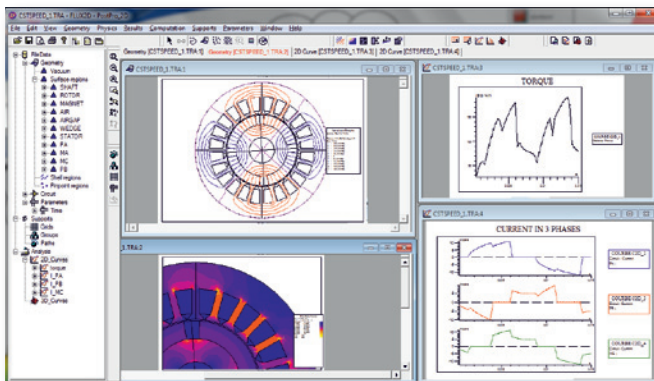
Flux and Motor Overlays feature modern graphical user interface from pre to post processing

Eddy currents in the magnets of a BPM machine.

Flux Motor Overlays
BPM   IM   SRM   DC

Import • SPEED • Motor-CAD

Flux by CEDRAT

Driving Flux with scripts

Optimization GOT-It by CEDRAT

### Automated tool and library of components

The provided **libraries of components** (rotor types, slots shapes, windings) feature most common components used in the motor industry. As an example, more than 40 different rotor topologies and over 20 stator slots are available in BPM Overlay. Those libraries are completed by **numerous features** (slits, eccentricity, cooling holes, bifurcated teeth, lamination shape, …) whose dimensions and number are **customizable**.

For induction machines, specific squirrel cage electric component enables representing the complex circuit in a faster way and in a simple component.


Examples of rotor bars available in IM Overlay.

Windings can be specified from a list of predefined classical windings, or can be customised.
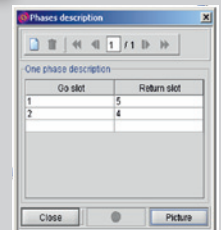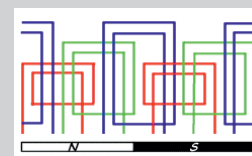
No Finite Elements skills needed

Defined out of well chosen parameters, the motor model does not require any skills in Finite Element modelling. Finite Element mesh is indeed **totally driven by a single and editable parameter**. From 0 (coarse mesh) to 1 (tight mesh), this single value will provide accurate and refined mesh to the model and let the engineer concentrates on the design itself.
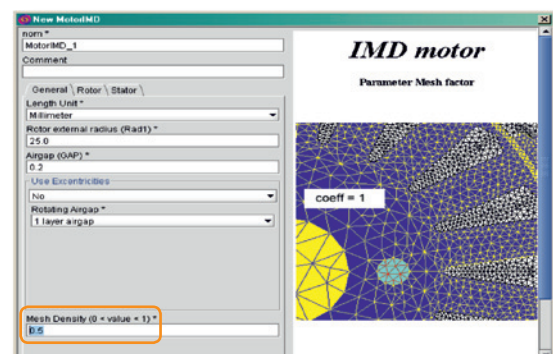
Model's mesh is fully driven with a single parameter.

CEDRAT,
30 years of experience
in Electrical Engineering

Guiding your
Technical Innovation

7 modeling and simulation tools, 11 international partners, 30 years of experience and more than 50 engineers, developers and consultants.

With its expertise in the field of Electrical Engineering, CEDRAT and its multidisciplinary team of engineers offers innovative solutions and top of the line tools geared towards the specific needs of each industry.

Strong of its tied connections with industries and research institutes, including a close collaboration with G2Elab, CEDRAT focuses on today and tomorrow's goals of energy efficiency, cost reduction and smart features.

Not just tools!

Long term experience in both software development and consulting work make CEDRAT and its distribution network a valuable partner to support and train you when using our software. Training and support competencies:

- Use of the programs
- Numerical methods
- Adapted methodology
- Application/ Device Specific
- Limits of the models' validity
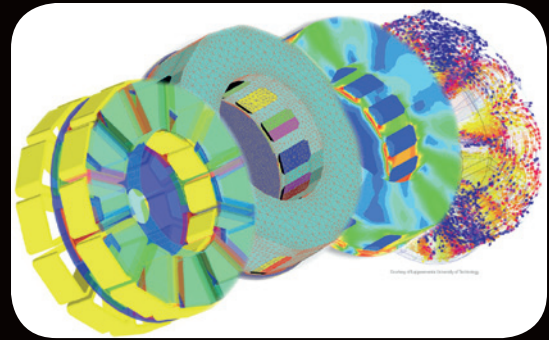- Customer's models resolution

Consulting services

Lack of competence? Temporary overloaded department? Missing software know-how? Improvement on methodology needed? CEDRAT provides consulting and computation services.

A team of experienced design engineers is available to create, design or optimize innovative solutions. If you are interested in contracting our consulting services, please contact us or visit our website.

Quality assurance

Flux is controlled and developed under Quality Assurance procedures. It ensures a constant validation of the capabilities and the results of the software.

References

ABB, Alstom, BMW, Bosch, Continental Automotive, Delphi Automotive, FAURECIA, Faulhaber Motoren, Grundfos, Hyundai, Leroy Somer, Liebherr Aerospace, Magneti Marelli, PSA, Renault, Rockwell, Samsung, SEW Eurodrive, SMH Automobiles, Struckmeier, Suzuki Motors, TVS Motor, Valeo …

CEDRAT S.A.
15 chemin de Malacher • Inovallée
38246 MEYLAN CEDEX • FRANCE
Phone: +33 (0)4 76 90 50 45
Fax: +33 (0)4 56 38 08 30
Email: cedrat@cedrat.com

[www.cedrat.com]

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www.magsoft-flux.com

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for Europe & the Middle East
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