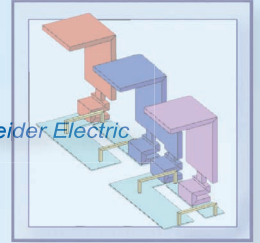


## On InCa trail...

Yann LEFLOCH, Sebastien CADEAU-BELLIARD, Cedrat S.A, Jean-Paul GONNET, Vincent MAZAUURIC, Schneider Electric



Far from the famous South American trek path, this road leads to one of the most innovative and efficient solution to model connections with electrical equivalent circuits.

InCa stands for Inductance Calculation, and is mainly dedicated to power electronics and power engineering applications (computation of over-voltage during commutations, EM compatibility, loop inductance...). InCa is based on the PEEC method.

### PEEC Method

The Partial Element Equivalent Circuit (PEEC) method was initially developed for PCB applications, but it proved to be efficient for the design optimization of 50-60 Hz electrical distribution systems. This method appears as a good complement to finite element methods for optimization, as it allows us to model both skin and proximity effects in multiconductor systems with a 'pipe' approach, thus avoiding the cumbersome meshing of air.

### Principle

Following several works and PhDs carried at LEG, Schneider Electric and MGE-UPS (Jean-Paul Gonnet, Edith Clavel, Jean-Michel Guichon, Christian Martin among others) and a contract with Schneider Electric, InCa sees now a second birth.

Its principle is described in figure 1.

Figure 1: How InCa works.

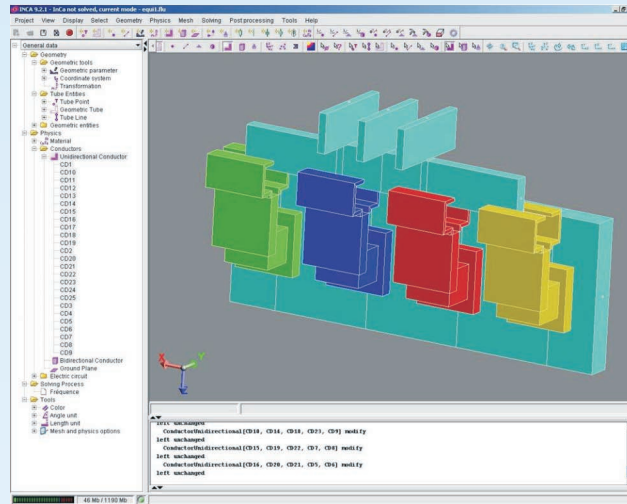
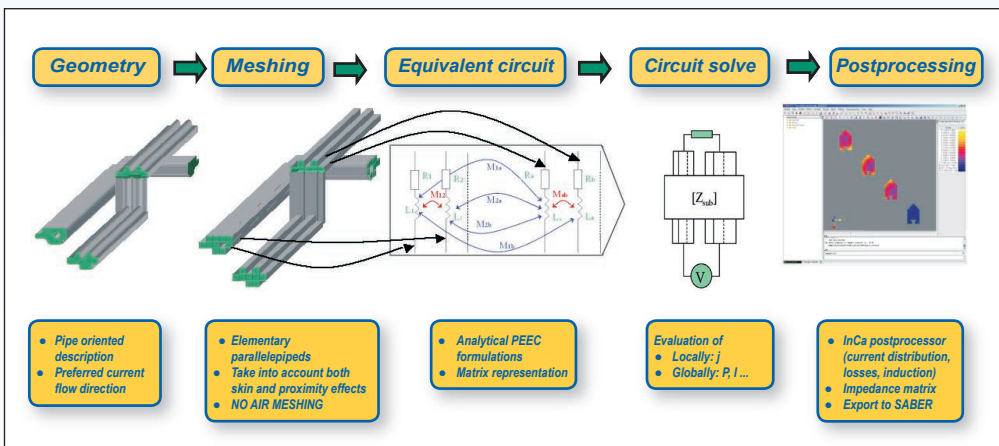


Figure 2: Geometry in InCa.

Modelling is completely integrated in the same interface and follows 5 steps:

### Geometric description

The geometry may be described in 2 ways:

- Pipe description: the user defines the average path of the conductors, with a rectangular cross section. In that case, the conductor is unidirectional and defaults to be made of copper.
- Classical CAD geometric definition (the geometry is then made of volumes). The conductor can be:
  - Unidirectional: Faces represent the terminals,
  - Bi-directional. The user defines a plan in which the current may flow. Points, lines and faces can then represent the terminals in that particular case.

### Mesh

Using the first method to define the

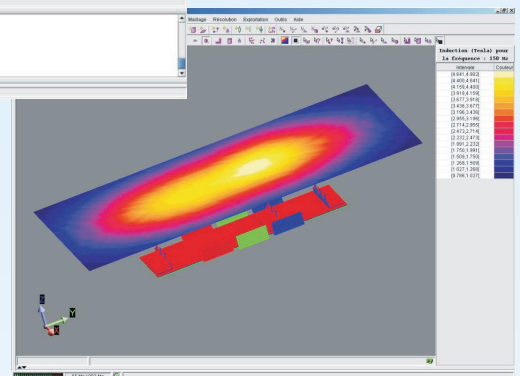


Figure 3: Field radiated by a busbars (MGE-UPS).

geometry will lead to an automatic PEEC mesh that will depend on frequency, in order to account for skin depth. When the geometry is defined as in classical geometry, the user defines the number of elements in the conductors.

### Generation of an equivalent circuit

This is a transparent step for the user using the PEEC method.

### Solving

The user may choose between two solving options:

- Impedance computation: this generates a simplified matrix of system impedance, and a MAST file.
- Current computation: to compute the current distribution in the system.

### Post-processing

InCa has an integrated postprocessor that provides different types of results:

- For current computation - current density,

(continued on page 11)

## On InCa trail... (continued)

Yann LEFLOCH, Sebastien CADEAU-BELLIARD, Cedrat S.A,  
Jean-Paul GONNET, Vincent MAZAURIC, Schneider Electric.

- losses,
- induction,
- Laplace forces...
- For impedance computation:
- export of the impedance matrix,
- export to SABER (MAST files).

So far, InCa has two main limits:

- All materials have a relative permeability equal to 1.
- Conductors are normal or parallel to each other.

### Applications

InCa has been used for several applications. One application example is the study of currents in bus bars. This study, carried out by LEG (Laboratoire d'Electrotechnique de Grenoble) and MGE-UPS (Uninterruptible Power Systems manufacturer), led to the optimisation of current waveform in the power module, changing the connection in this power module (see figure 4).

A second example (see figure 5)

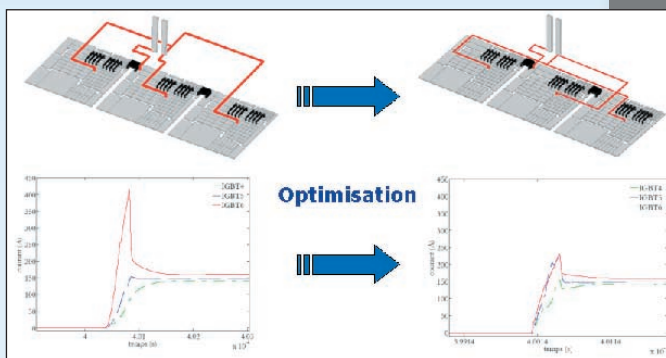


Figure 4: optimisation of current waveform in the power module.

is the study of current density in distribution bars (made by Schneider Electric). In this instance, the goal was to reduce Joule losses by varying the position of the bus bars. Taking into account temperature and skin effect, losses in the distribution bars could be reduced by 25 %.

### Collaboration

This work has been done thanks to an extensive collaboration

and the financial support of Schneider Electric. May they be thanked with this article.

### On the market

InCa's first integrated release will be on the market by summer. Please ask [software@cedrat.com](mailto:software@cedrat.com) any question about this new product.

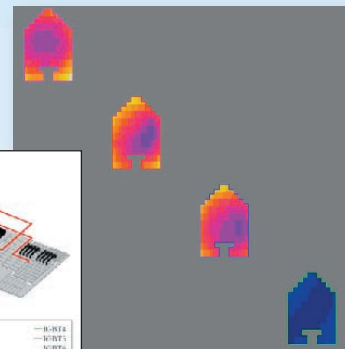
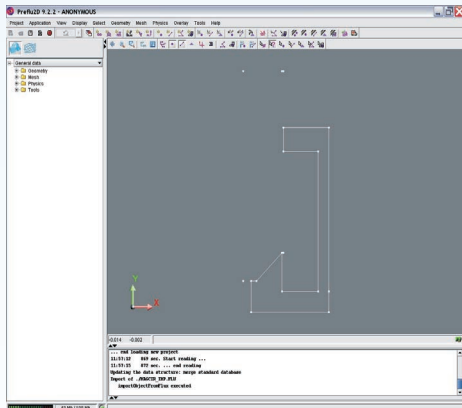


Figure 5: Current distribution in the bars.

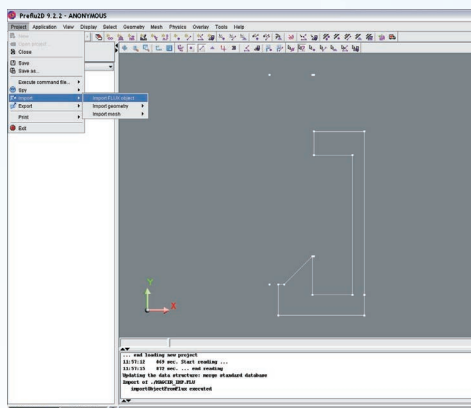
## How to: Run an electromagnet simulation with FLUX.

Sébastien CADEAU-BELLIARD, Cedrat S.A..

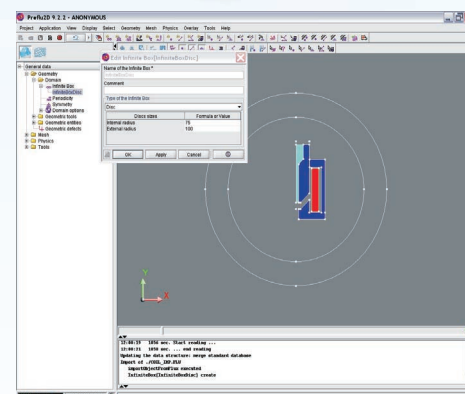
Through a series of pictures, you will be given a tutorial dedicated to linear actuators. 12 screenshots show you how to run an electromagnet simulation with FLUX.



Geometry: Points can be parameterised so that the parameters can be modified later on.



Geometry: But you can also complete the geometry importing objects you have already created (import with mesh and parameters).



Geometry: The domain can be closed with an infinite region.

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