EPE tutorial

TITLE

Analytical Modelling and Optimisation Techniques and Tools for the Design of Electrical Components and Systems: application to electrical machines, power electronics and electrical drives

NAME AND AFFILIATION OF THE AUTHORS

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SCOPE AND BENEFITS

The first steps of design process, in which the first choices are made (choice of structure, first study of feasibility…) are of critical importance in the design, since decisions taken in those steps, fix 80% of the total cost of the project. The most often, the only tools available in those steps are, for example, Excel or Matlab files, and the methodology is iterations by hand. This tutorial proposes tools and methodologies; based and the use of analytical and semi-analytical models, coupled to optimisation technics in order to improve this state of art.

Thus, the proposed tutorial aims to introduce the use of common optimisation algorithms, for the sizing or pre-sizing (with numerous constraints) of electrical devices and systems. A methodology to address the optimisation of electrical devices with numerous constraints will be presented and applied to practical problems using CADES Framework. From this methodology, the audience will have the basic knowledge to develop their own optimisation-oriented models and to use some common optimisation algorithms for design applications.

CONTENTS

The course deals with the design of electrical component or systems, using analytical or semi-analytical models. Existing tools will be presented to the attendees in order to show how it is possible to simplify the programming and modelling tasks during design process:

- models of electromagnetic devices described by *reluctance networks*;
- analytical models using *simple analytical equations (implicit or not, linear or not)*;
- analytical models *with the call of external function in native code or the call of numerical frameworks* (e.g. Matlab);
- optimisation with common algorithms such as:
  - Sequential Quadratic Programming (SQP): in this case, the Jacobian is automatically built and programmed thanks to the use of CADES Framework;
  - Genetic Algorithm (GA);

In addition, Pareto analyses will be introduced for the purpose of multi-objective optimisations (best compromises between weight and losses for example).

More particularly, three applications will be proposed. The practical courses will be divided into two parts. During the first part, the three applications will be presented in parallel and each

attendee will choose one particular application to study with details both modelling aspects and optimisation methods. During the second part, the other applications will shortly studied, just to discover some modelling and optimisation specificities. The applications are the following:

- modelling and sizing by optimisation of a permanent synchronous machine (analytical modelling and reluctance network modelling);
- modelling and sizing of a power electronics converter : a voltage inverter for electrical drive application, a flyback will also proposed if someone is interesting
- modelling and sizing of a synchronous machine fed by a voltage inverter

A complete and complex application with multi sources and with multi loads will be presented at the end of the tutorial.

During the tutorial, a version of CADES framework can be installed in a computer room at the university of Lille, or on the laptops of the audience. For the attendees who are not able to install software on their own computer, it will be possible to download the software environment before the conference.

Monday, September 2nd - Tutorial day (Location: University of Lille)

08:00 - 09:30 Registration for **Tutorials**

09:30 - 11:00 Tutorials Part 1

Theory: The theoretical importance of initial steps in design (sketch-up), the theoretical added value of semi-analytical value and optimisation in those steps
The methodology: optimisation-oriented modelling, synthesis of optimisation algorithms
Presentation of the modelling and optimisation framework, basic use on a very simple analytical model of an electric device

11:00 - 11:30 Coffee break

11.30 - 13:00 Tutorials Part 2

- Presentation of the three applications : the attendees will deal the entire approach on one application and see the other only on result aspects
- Choice on the main application to be studied by each participant
- Modelling steps: the aim of this part is to understand how to define a sizing-oriented model suitable for optimisation; however the models will be given to the audience
- The attendees will define the sizing criteria

13:00 - 14:00 Lunch break

14:00 - 15:30 Tutorials Part 3

- Sensibility analysis, definition of the specifications
- Use and understanding of the three algorithms (SQP, GA, multi-objective optimisation), algorithm convergence and discussions

15:30 - 16:00 Coffee break

16:00 - 17:30 Tutorials Part 4

- Modification of the specifications
- Modification of the modelling
- New optimisations
- Presentation of a complete study: application with multi sources and with multi loads
- Interoperability demonstration: Interactions between numerical and optimisation environment:
  - optimisation by Matlab and modelling by CADES,
  - optimisation by CADES and modelling by Matlab.

17:00 - 19:00 Possibility for registration for the EPE2013 ECCE Europe in the lobby of Lille Grand Palais

WHO SHOULD ATTEND

Any engineer or researcher in electrical engineering who wants to deals with the design of electrical components or systems, using optimization algorithm. The attendees should have a basic level of knowledge in power electronics and electrical machines.

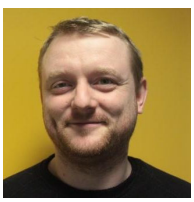
Technical Level: beginners

ABOUT THE INSTRUCTORS

Petre Enciu is RD Engineer in Vesta-System, where is in charge of the development of Cades Framework and applications. He is specialized on machine models and optimizations methods. He is co-founder of Vesta-System, that he jointed after his PHD in G2ELAB on "Automatic derivation of models and algorithms for sizing and design in electrical Engineering".

Christophe Espanet is professor in electrical engineering at the University of Franche-Comte and he is the head of the special machines research team at the Energy department of FEMTO-ST Institute in Belfort (France). His research interests include the modeling and the design of electrical systems and in particular PM synchronous machines. He has also developed in the University of Franche-Comte several courses about the design and optimization of electrical machines.

Laurent Gerbaud is professor in electrical engineering at Grenoble-INP and practices his research at the G2Elab (Grenoble Electrical Engineering Laboratory). His researches deals with computer aided design of electrical systems, mainly electrical drives and power electronics applications. This includes the aid for the analytical modelling of electrical components and systems, time and frequency simulations, design and sizing methodologies by optimisation, design of CAD tools and frameworks.



Franck Verdière is RD Engineer in Vesta-System, where is in charge of the development of Cades Framework and applications, where is specialized on languages and composition language for optimizing systems. He jointed Vesta-System after his Phd work on the development of methods and tools for sizing and optimizing machines and converters.

Frédéric Wurtz was born in France in 1970 and took his degrees in Electrical Engineering in 1993 at the Institut National Polytechnique de Grenoble. He obtained his Ph-D in 1996. He is now researcher at the CNRS since 1998 and work at the G2ELAB (Grenoble Electrical Engineering Laboratory). His research regards the design process of electromagnetic devices and develops methods and tools in this area. This last years, he his developing new skills in the area of design of systems for energy managements: typically cars, flights, buildings and smart grids.