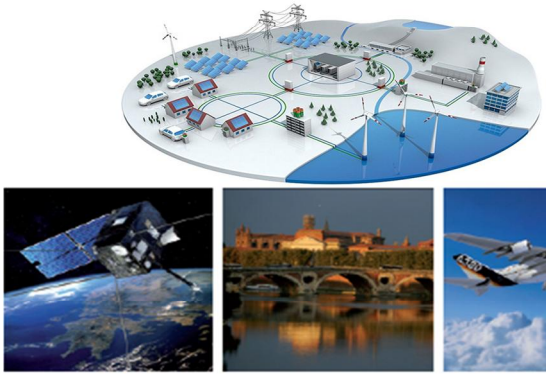
International Conference on Modeling and Simulation of Electric Machines, Converters and Systems



ELECTRIMACS 2017

ENSEEIHT Toulouse
July 4-6th 2017

Welcome message

On behalf of the Organising Committee, it is a great pleasure and an honour to welcome you in the "ville rose" of Toulouse for the 12th International Conference on Modeling and Simulation of Electric Machines, Converters and Systems (ELECTRIMACS 2017).

It is now the 33th anniversary of the 1st ELECTRIMACS conference held in Liege, 1984, followed by editions held in Québec (1987), Nancy (1990), Montréal (1993), Saint Nazaire (1996), Lisbon (1999), Montréal (2002), Hammamet (2005), Québec (2008), Paris (2011) and Valencia (2014).

ELECTRIMACS, the main conference of the IMACS Technical Committee 1 (TC1) on Modeling and Simulation of Electrical Systems, continues in Toulouse its long tradition of being a meeting point for researchers to share ideas the fields of Electrical Machines, Converters, Systems and applications.

The technical program will include three Plenary Sessions, with renowned speakers from academia (Marco Lissere, Univ of Kiel) and from industry (Lennart Harnerfors, ABB and Jérome Faucher, Airbus) and three parallel tracks plus nine special sessions with oral presentations from 19 different countries. These papers have been selected from more than 145 submissions received.

ELECTRIMACS 2017 has been organised by the Université de Toulouse, especially the Institut National Polytechnique of Toulouse and will be held in the ENSEEIHT engineering school. Two research labs have cooperated to manage the conference: the LAAS and the LAPLACE.

We would like to thank all the individuals and institutions who contributed to the organisation of ELECTRIMACS 2017: the local organising committee, the electrimacs Secretariat, the technical program chairs, the track and special session chairs, the members of the IMACS TC1 international committee, the scientific committee, the reviewers. We also thank the ENSEEIHT staff for help in the organisation of the conference. We would like to thank the keynote speakers and special session organizers for their contribution to the conference. Particularly, we would like to thank the president of the IMACS TC1 Committee, Prof. Eric Monmasson, for his support for the organisation of ELECTRIMACS 2017. We also warmly thank Prof Ramon Blasco Gimenez who organised Electrimacs'2014 in Valencia and who shared with us his experience with numerous advices.

We would like to thank the IMACS president Prof. Rosa Maria Spitaleri and IMACS treasurer Prof. Beauwens for their long standing support of ELECTRIMACS, and for dedicating a special issue of the IMACS MATCOM journal to ELECTRIMACS 2017.

We would like to thank the IEEE Industrial Electronics Society and IMACS, our technical co-sponsors. We would also like to express our gratitude to our industrial sponsors (IRT St Exupery) and exhibitors (dSpace, Typhoon HIL, Power Design Technologies and OPAL-RT) for their contribution to the conference as the worldwide leaders in many important areas of interest of ELECTRIMACS. Besides the organising universities, the help of our institutional sponsors has been very important to the success of ELECTRIMACS, especially the Région Occitanie.

Last but not least, we would like to thank all the authors and attendees because the scientific success of ELECTRIMACS 2017 surely belongs to them.

Xavier Roboam

ELECTRIMACS 2017 General Chair

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I. Belkhodja, Tunisie

Track 2. Methods for control and power management
M. Malinowski, Poland
M. Fadel, France
C. Dufour, Canada
N. Patin, France

Track 3. Methods for system design and optimization
B. Sareni France,
S. Pierfederici, France,
J.P. Fernandez Trovao, Canada,
B. Allard, France

Special Sessions
EMR and Other Graphic Descriptions: Application to EVs and HEVs
W.Lhomme, J.P. Fernandez Trovao

Microgrids
M Sechilariu, G. Spagnuolo

Thermal Management of power electronics and electrical machines
Y. Bertin, C. Henaux

Diagnostics & Monitoring:
H. Razik, A. Soualhi

Hybrid Energy Storage Systems for Vehicular Application
A. Castaings, L. Boulon

High Voltages, Plasmas and Pulsed Power Applications
H. Piquet, L. Pecastaing

Modelling and Tools for Power Converters Design
G. Fontes, J. Cros

Modeling and Control of Advanced Power Electronics for Renewable Energy and Power Quality
M. Fadel, H. Kanaan

Optimized Control and Modeling of Electric Machines
V. Lanfranchi, D. Depernet

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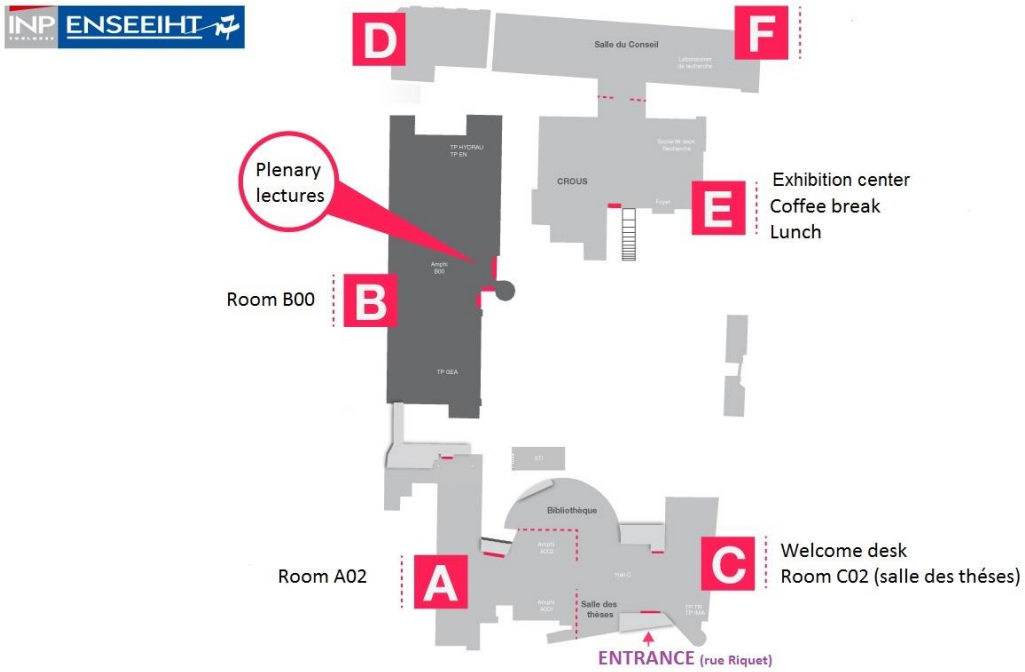
General information

Conference venue

Because of construction, the address will be:
ENSEEIHT
26 Rue Riquet
31071 TOULOUSE
FRANCE
(the address "2 rue Camichel" is not available)



Internet access

Free wireless Internet access will be provided to all participants. Please, do bring a laptop, tablet or smart phone with Wi-Fi connection. The access code is :
Network :wifinp
Login : guest_7312
Password : AfT9aR7

Alternatively, if your home institution is a member of eduroam, you should be able to connect to our eduroam wireless network directly.
And we inform you that the room C106 (1st floor in building C) is a computer room for internet access only.

Presentation guidelines

All ELECTRIMACS presentations are oral.

Every author presenting a paper is kindly requested to meet his/her session co-chairs in the session room 15 minutes before the start of the scheduled session in order to upload his/her presentation in the computer.

The presenter must provide the session chairs or the technical assistant with a PowerPoint or PDF presentation on a USB pen drive. **It is not possible for presenters to connect their own portable computers to the projector.**

A printed short bio of not more than 8 lines should also be handed to the session chairs, so speakers can be properly introduced.

The length of each presentation is restricted to 20 minutes, including questions. The authors are encouraged to conclude their oral presentation within 15 minutes (around 15-20 slides) and allow 5 minutes for questions and discussion.

No show papers will not be included in the proceedings nor be eligible for publication in the Special Issue of the IMACS MATCOM journal.

Session Chairs

Session chairs have the responsibility to ensure that the schedule is strictly respected. Each presentation plus questions should not exceed 20 minutes.

In the event of “no-show”, the session chair should wait 20 minutes for the next paper or close the session if it is the last paper.

The session chair will read the brief bio handed by the presenter to introduce the speaker before his or her presentation.

All the rooms will be equipped with a video projector and a screen. A member of the conference technical staff will assist the session chairs for the duration of the complete session.

Each session chair is kindly requested to **fill a form (one per session) with the evaluation of all papers** in the session and hand it back to the registration desk or give it to the technical assistant.

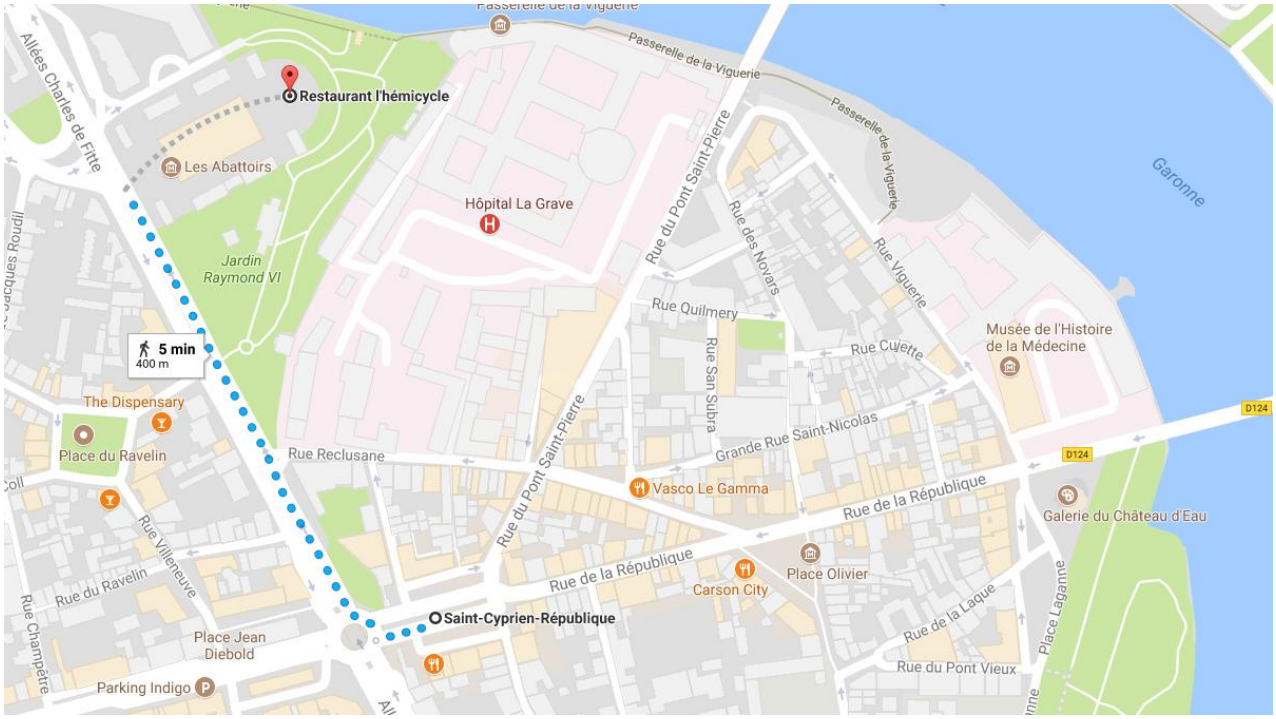
Social Events

Welcome cocktail

On Tuesday July 4th – 7:30 p.m

L'Hémicyle
« Café-Restaurant » of Abattoirs museum
76 Allées Charles de Fitte, 31300 Toulouse

Métro A : Saint-Cyprien-Republique
5 min walking



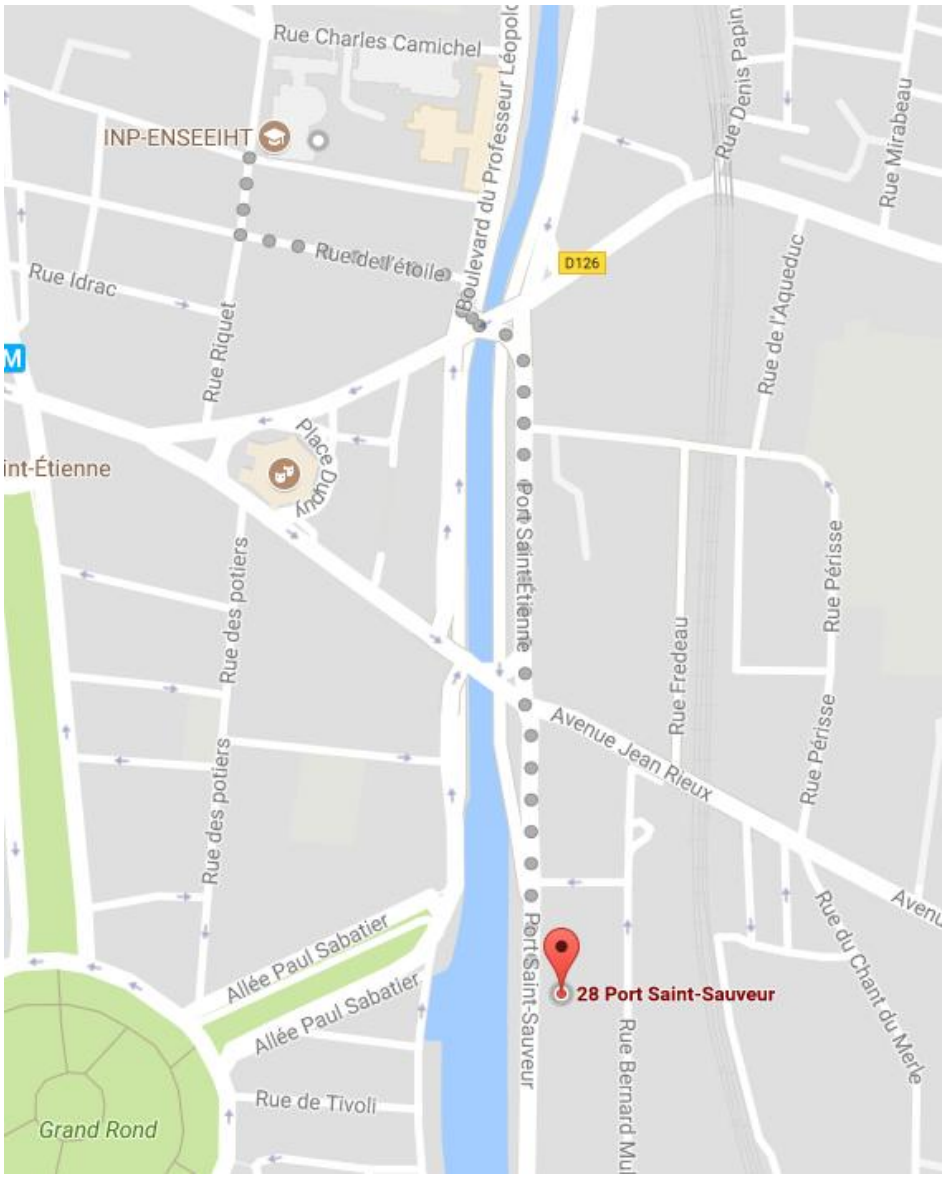
Gala dinner

(*Only on registration*)

On Wednesday July 5th

Cruise on "Canal du Midi" (UNESCO site) and dinner at
Le Mas des canelles, Castanet Tolosan

6:10 pm: meeting point at the welcome desk of the conference (Hall C)
6:15 pm: Boarding at "28 Port saint Sauveur" (near the conference site).



8 pm: Aperitif and dinner at Mas des Canelles
11 pm: 1st bus return
11:15 pm: 2nd bus return
11:30 pm: 3rd bus return
Stop at ENSEEIHT (conference site)
Stop at Jean Jaures (Metro A & B)
Stop at Jeanne d'Arc (Metro B)
Stop at Compans Cafarelli (Metro B)

Tuesday 4th	from 8.00 am Registration		
	room B00	room C02	room A02
	9.00-9.30 am Opening ceremony		
	9.30 - 10.20 am Keynote 1 - M. Liserre Chair: Eric Monmasson "The Smart Transformer: impact on the electric grid and technology challenges" Kiel University Germany		
	10.20-10-40 am coffee break, room 'foyer'		
	10.40 - 12.40 Session 1.a (6 papers) Chair: Corinne Alonso, Ramon Blasco Gimenez Smart Home, building integrated PV paper ID: 46, 48, 75, 88, 111, 155	10.40 - 12.40 Session 1.b (6 papers) Chair: Rafael Diez, Guillaume gateau Control and design of power electronics paper ID: 11, 43, 51, 71, 104, 162	10.40 - 12.40 Session 1.c (6 papers) Chair: Hubert Razik, Abdenour Soualhi Special Session Diagnostics & monitoring paper ID: 26, 35, 99, 137, 161, 163
	12.40-2.00 pm lunch @ room 'foyer'		
	2.00 - 4.00 pm Session 2.a (6 papers) Chair: Hadi kanaan, Maurice Fadel Special Session Modeling and Control of Advanced Power Electronics for Renewable Energy and Power Quality paper ID: 22, 121, 128, 133, 150, 151	2.00 - 4.00 pm Session 2.b (6 papers) Chair: Domenico Casadei, Stéphane Caux Control methods for electric machines paper ID: 40, 45, 64, 105, 117, 141	2.00 - 4.00 pm Session 2.c (6 papers) Chair: Ilhem Belkhodja, Maria David Diagnostics & control for wind power applications paper ID: 10, 28, 32, 49, 63, 119
	4.00-4.30 pm coffee break room 'foyer'		
	4.30 - 6.10 pm Session 3.a (5 papers) Chair: Guillaume Fontes, Jerome cros Special Session Modelling And Tools for Power Converters Design paper ID: 79, 82, 129, 147, 157	4.30 - 6.10 pm Session 3.b (5 papers) Chair: Walter Lhomme, Joao P. Trovao Special Session EMR and Other Graphic Descriptions. Application to EVs and HEVs paper ID: 18, 66, 101, 109, 152	4.30 - 6.10 pm Session 3.c (5 papers) Chair: Vincent Lanfranchi, Daniel Depernet Special Session Optimized Control and Modeling of Electric Machines paper ID: 13, 31, 52, 84, 106
	7.30 pm Welcome party @ Hémicycle		

Wednesday 5th	from 8.00 am Registration		
	room B00	room C02	room A02
	8.30-9.20 am Keynote 2 - J. Faucher Chair: Louis Dessaint “Advanced design tools for Aircraft Electrical Networks: application to More Electrical Aircraft”, Airbus Operations		
	9.30 - 10.30 am Session 4.a (3 papers) Chair: Ali Castaings, Kamal Al-Haddad Special Session Hybrid Energy Storage Systems (H-ESSs) for Vehicular Application paper ID: 98, 116, 132	9.30 - 10.30 am Session 4.b (3 papers) Fuel Cells Chair: Amine Jaafar, Hamid Gualous paper ID: 67, 102, 114	
	10.30-11.00 am coffee break, room 'foyer'		
	11.00 - 12.40 Session 5.a (4 papers) Chair: Laurent Pecastaing, Hubert Piquet Special Session, High Voltages, Plasmas and Pulsed Power Applications paper ID: 65, 103, 115, 146	11.00 - 12.40 Session 5.b (5 papers) Chair: Christophe Turpin, Daniel Depernet Fuel Cells & storage systems Paper ID: 94, 100, 125, 127, 131	11.00 - 12.40 Session 5.c (5 papers) Chair: Nicolas Bernard, Ulrich Werner Design & optimization of electric machines paper ID: 24, 44, 69, 72, 154
	12.40-2.00 pm lunch @ room 'foyer'		
	2.00 - 4.00 pm Session 6.a (6 papers) Modelling & Analysis of power electronics Chair : Bernardo Cogo, Frédéric Richardeau paper ID: 5, 62, 77, 83, 95, 108	2.00 - 4.00 pm Session 6.b (6 papers) Special Session Microgrid 1 Chair: Manuela Sechilariu, Giovanni Spagnuolo paper ID: 7, 19, 20, 21, 56, 122.	2.00 - 3.40 pm Session 6.c (5 papers) Renewable energy Chair: Benoit robyns, Nicolas Roux paper ID: 27, 73, 74, 89, 140
	2.00-4.20 pm coffee break, room 'foyer'		
	4.20 - 6.00 pm Session 7.a (5 papers) Chair: Carlole Henaux, Yves Bertin Special Session Thermal Management of power electronics and electrical machines paper ID: 8, 50, 93, 96, 144	4.20 - 6.00 pm Session 7.b (5 papers) Chair: Manuela Sechilariu, Giovanni, Spagnuolo Special Session Microgrid 2 paper ID: 124, 136, 139, 153, 160	4.20 - 6.00 pm Session 7.c (5 papers) Chair: Nicolas Patin, Yvan Lefevre Modeling & simulation of electric machines & electromagnetic devices 1 paper ID: 17, 42, 61, 85, 134
	6.10 pm Meeting point at welcome desk (bat C) before starting cruise on canal du midi for Gala dinner @ Mas des Canelles (Castanet Tolosan)		

	room B00	room C02	room A02
Thursday 6th	9.00-9.50 am Keynote 3 - L. Harnefors Chair: Philippe Iadoux “The Evolution of HVDC Transmission” ABB AB Corporate Research, Sweden		
	9.50-10.20 am coffee break, room 'foyer'		
	10.20 - 12.20 Session 8.a (6 papers) Chair: Babak Nahid, Jean paul Gaubert Islanded & DC microgrids paper ID: 15, 47, 81, 107, 120, 123	10.20 - 12.20 Session 8.b (6 papers) Chair: Georges Barakat, Flavia Khatounian Modeling & simulation of electric machines & electromagnetic devices 2 paper ID: 4, 112, 113, 135, 138, 145	10.20 - 12.20 Session 8.c (5 papers) Chair: Emmanuel Vinot, Yang Nanfang Transportation & embedded network applications paper ID: 30, 33, 55, 76, 90
	12.20-2.00 pm lunch @ room 'foyer'		

Keynote 1

The Smart Transformer: impact on the electric grid and technology challenges

LISERRE, Marco

Kiel University Germany
ml@tf.uni-kiel.de

Marco Liserre received the MSc and PhD degree in Electrical Engineering from the Bari Polytechnic, respectively in 1998 and 2002. He has been Associate Professor at Bari Polytechnic and Professor at Aalborg University (Denmark). He is currently Full Professor and he holds the Chair of Power Electronics at Christian-Albrechts-University of Kiel (Germany). He has published over 300 technical papers (more than 86 of them in international peer-reviewed journals) and a book. These works have received more than 20.000 citations. Marco Liserre is listed in ISI Thomson report "The world's most influential scientific minds".

He is member of IAS, PELS, PES and IES. He has been serving all these societies in different capacities and he has received several IEEE awards. He is an IEEE Fellow from 2013.

He has been awarded with an ERC Consolidator Grant for the project "The Highly Efficient And Reliable smart Transformer (HEART), a new Heart for the Electric Distribution System".

Abstract:

The increasing connection of renewables and new loads is challenging the distribution grids. The Smart Transformer (a power electronics-based transformer with control and communication functionalities), can provide ancillary services to the distribution grids to support the grid management, in addition to the voltage adaptation.

The Smart Transformer is a natural connection point for hybrid (AC and DC) grids both at MV and LV levels and offer an optimal possibility to integrate storage and electric vehicles charging stations.

The keynote will define the concept of Smart Transformer presenting the topologies and controllers and highlighting how the ST can be modelled. New services enabled with the Smart Transformer technology, for instance load sensitivity evaluation in LV grids and voltage and frequency regulation in MV/HV grids, are explained, showing the laboratory validation through HIL and PHIL.

The technological challenges of the DC/DC converter with examples from prototypes built in the Power Electronics Laboratory at the University of Kiel are described.

Finally the design of the Smart Transformer as a grid-tailored Solid-State-Transformer will be presented.

Keynote 2

Advanced design tools for Aircraft Electrical Networks: application to More Electrical Aircraft

Jerome Faucher,

Electrical system engineer, Airbus electric system department.

Jerome Faucher received the MSv and PhD degree in Electrical Engineering from Toulouse INPT, respectively in 2003 and 2006. He is currently working for Airbus in the electric system research team.

Abstract:

More and more electric systems are embedded in today aircraft. As a result, the complexity of electrical power system design is increasing and the need of generic and efficient design methods is today required.

The keynote will present how advanced design methods & tools can support electrical designer to manage high combinatorial design problems in order to reduce weight impact at electrical network level.

Keynote 3

The Evolution of HVDC Transmission

Lennart Harnefors

ABB, Sweden

Brief cv:

Lennart Harnefors received the Ph.D. degree in electrical engineering from KTH Royal Institute of Technology, Stockholm, Sweden in 1997 and the D.Sc. degree in industrial automation from Lund University, Lund, Sweden in 2000. Between 1994 and 2005, he was with Malardalen University, Vasteras, Sweden, from 2001 as a Professor of electrical engineering. He was in addition a part-time Visiting Professor of electrical drives with Chalmers University of Technology, Gothenburg, Sweden between 2001 and 2004.

In 2005 he joined ABB and the HVDC product group in Ludvika, Sweden. There, he served as R&D Project Manager for HVDC Light until he joined ABB Corporate Research in Vasteras in 2012. He currently holds a position as Senior Principal Scientist and is in addition a part-time Adjunct Professor of power electronics with KTH Royal Institute of Technology. His research interests are in control and dynamic analysis of power electronic systems. He is a Fellow of the IEEE.

Abstract:

The Evolution of HVDC Transmission

High-voltage direct-current (HVDC) transmission technology has undergone significant development over the (more than) 60 years that the technology has been in existence. A great deal of this development has taken place over the last 20 years, with the introduction of voltage-source-converter (VSC)-based HVDC. Originally aimed for HVDC transmission of relatively low power rating, VSC HVDC today is a contender to classical line-commutated-converter HVDC even in transmissions rated up to several gigawatts. In this keynote we highlight the important steps in the evolution of HVDC transmission. The development from two- and three-level topologies to the currently used modular multilevel converter (MMC) topology is illustrated. VSC HVDC transmission allows fast control of the active and reactive powers at both terminals. Examples of how this can facilitate improved performance and stability of power systems are given. Finally, examples of successful HVDC installations and the premises for building them are presented.

Session 1 a

Smart Home, building integrated PV

ID 46

Relevant feature selection for home appliances recognition

HOUIDI, Sarra (1,2); AUGER, François (1); BEN ATTIA SETHOM, Houda (2); FOURER, Dominique (1); Miègeville, Laurence (1)

1: Institut de Recherche en Energie Electrique de Nantes Atlantique (IREENA) Université de Nantes; 2: Laboratoire de Recherche des Systèmes Electriques (LSE ENIT) Tunis, Tunisie

All over the world, the residential sector represents an important part in electrical energy consumption, and thus, is an opportunity to address substantial savings in terms of energy and money. In order to attempt this objective, a relevant knowledge of the appliances used in residential buildings is needed in order to better control or monitor energy consumption. This will be made possible through an effective automatic recognition of the home appliances. In this context, the main objective of this work is to be able to describe appliances as best as possible in order to recognize them individually, using features deduced from current and voltage measurements recorded at the grid connection point. In this paper, methods for selecting the most relevant features allowing the recognition of home appliances are proposed. The set up of a database of sampled measurements recorded on various home appliances types is also introduced.

ID 48

IMPLEMENTATION OF A PREDICTIVE DEMAND SIDE MANAGEMENT OF A RESIDENTIAL HOUSE UNDER INTERMITTENT PRIMARY ENERGY SOURCE CONDITIONS WITH A PV-BATTERY BACKUP SYSTEM

Khoury, Jawad (1,2); Mbayed, Rita (2); Salloum, Georges (2); Monmasson, Eric (1)

1: University of Cergy-Pontoise, France; 2: Lebanese University, Lebanon

This paper implements a predictive residential demand side management program on a standalone ARM cortex-A9 processor suitable for an on-field application. A high energy consuming residential application is applied under intermittent primary energy source conditions. A PV-battery backup system is in- stalled in order to replace the grid during the frequent and periodic electricity blackouts. The implemented management program controls the predictable de- vices in order to prevent the occurrence of loss of power supply to the house while maintaining high comfort levels to the inhabitants and respecting the operation constraints of the backup system. The developed program is formulated as an optimization problem and a weighted sum Genetic Algorithm (GA) is applied in order to find the optimal load operation schedule to be applied to the house. The implementation results show that the implemented load management accurately respected all the imposed constraints on the GA, showed significant flexibility of the program, and offered a high reliability level and remarkable performance regard- ing the case study. Additionally, it managed to consume low memory resources of the processor while providing a fast and extremely accurate decision making process.

ID 75

HLS-based architecture exploration for a SoC implementation of a dynamical reconfiguration algorithm for residential PV application

Serra, Fabio (1); Monmasson, Eric (2); Petrone, Giovanni (1); Spagnuolo, Giovanni (1)

1: University of Salerno, Italy; 2: Université de Cergy Pontoise, France

Some recent results presented in literature demonstrate that a stochastic algorithm aimed at the dynamical reconfiguration of a photovoltaic field can be fruitfully implemented in a system on chip. The computation time takes profit from the available field programmable gate array fabric, where multiple instances of the fitness function can be run in parallel. The proposed solution has allowed a significant reduction of the time needed for determining the new electrical configuration of the photovoltaic array that ensures the maximum power production. Although using High Level Synthesis to create a Register Transfer Language implementation from C/C++ sources allows to achieve satisfactory results, coding the algorithm while taking into account the synthesis process, thus resource allocation, scheduling and binding, allows to obtain a further performance improvement. This paper evaluates the interest of using a High Level Synthesis approach in order to systematically explore the possible architectures for implementing efficient time/area stochastic algorithm for real-time optimization of photovoltaic systems electrical interconnections among the panels. The target system on chip used is a cheap one.

ID 88

DC LOAD MODELLING AND DROOP CONTROL ANALYSIS FOR AUTONOMOUS RESIDENTIAL DC MICROGRID

MOUSSA, Sonia; BEN GHORBAL, Manel JEBALI; BELKHODJA, Ilhem SLAMA

ENIT, University of Tunis El Manar, LR 11 ES 15, L.S.E., B.P.37, 1002 Tunis, Tunisia.

Authors present DC load modelling and droop control analysis for small scale laboratory system emulating an autonomous residential DC microgrid. Different residential DC load types are considered. The impact of their connexion to a 48V DC bus and their parallel working into a DC microgrid are investigated. Droop control design is analysed to ensure DC micro grid safe working. Simulations are performed with PSIM Software to illustrate theoretical analysis.

ID 111

Safety analysis of a residential electrical installation for different V2H configurations in case of short-circuit

Ventoruzzo, Geraldine (1,2); Davigny, Arnaud (2,3); Henneton, Antoine (3); Gouraud, Sebastien (1); Robyns, Benoit (2,3)

1: Renault, France; 2: L2EP - Laboratire d'Electrotechnique et d'Electronique de Puissance, France; 3: HEI, France

Vehicle-to-Home (V2H) supposes that electric vehicle (EV) chargers are bidirectional. It is necessary to find the best solution to use a bidirectional EV charger in a residential installation in terms of safety, availability and cost. This paper shows a method to determine in case of a short-circuit occurrence in a residential installation, if goods safety and availability is ensured when the installation is supplied by an EV. The used method is based on the event-tree analysis: an event tree for the “short-circuit” event is proposed to determine the consequences in function of success or failure of intermediate events. Here, three configurations are considered: first, a residential installation supplied by the utility grid (reference configuration), secondly, supplied only by an EV and thirdly supplied by an EV and a PV system. After the weighting of intermediate event success and failure for each configuration, the event tree analysis reveals that the supply availability is very low in case of short-circuit for the two last configurations compared to the first configuration. It is due to the weak fault contribution of EV and PV system. The method proposed here can be applied to other configurations with other parameters.

ID 155

COMPARISON OF ELECTRICAL ENERGY PRODUCTION USING TWO SOLAR IRRADIATION MODELS OF BIPV

NEUHAUS, Kolja; PAPAS, Ilias; ESTIBALS, Bruno; ALONSO, Corinne

LAAS-CNRS, France

Amid growing needs for sustainable buildings and renewable energies, this paper presents a comparison between two different approaches of solar irradiation models for the production of electrical energy from photovoltaic (PV) panels. This project aims to evaluate the electrical energy produced from the sustainable building ADREAM, located in LAAS-CNRS, Toulouse. Initially, the Energy Simulation Software Pleiades+Comfie (P+C) was employed for the global Dynamic Thermal Modeling of the building. Thus, the P+C software served as a reliable tool for the modeling of the electrical production from the installed PV panels. In order to estimate the performance of this model, its accuracy was compared to that of an optimized solar irradiation model (Matlab), built from literature references. A description of the ADREAM building is provided, along with the methodology of the two simulations. The simulated results of PV energy production were compared to measured data. Finally, the two results were evaluated for the purpose of determining the most optimized modeling strategy.

Session 1.b

Control and design of power electronics

ID 11

Multi-port DC/DC converters for the More Electric Aircraft

Buticchi, Giampaolo; Liserre, Marco; Costa, Levy

University of Kiel, Germany

The More Electric Aircraft concepts aims at slowly replacing the hydraulic systems with electrical/electronic ones. In this scenario, the electrical power distribution system becomes of paramount importance. The latest standards envisage multiple voltage levels in the DC distribution system, pushing the development of DC/DC power electronics converters for this application. This paper proposes to use a Quadruple Active Bridge (QAB) DC/DC converter to interface high- and low-voltage DC buses. A decentralized control, based on virtual resistors, allows shifting the priority from one bus to another, enabling smart-grid operations. Simulation results in different cases show the potential of this concept.

ID 43

Director switches commutation control for the Alternate Arm Converter

Vermeersch, Pierre (1); Gruson, Francois (1); Guillaud, Xavier (1); Merlin, Michael (2); Egrot, Philippe (3)

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The modular multilevel converter (MMC) is the most accepted solution to connect a HVDC grid to an AC transmission grid. The Alternate Arm Converter (AAC) is another promising structure since it allows a DC short-circuits blocking capability similarly to the Full Bridge MMC while having a small impact on the power losses. Its footprint is smaller to the MMC since the needed number of modules is closer to 50% and the SM Capacitors are about three times smaller. The AAC is a hybrid structure between a 2 level VSC converter and an MMC one. Elements hampering the development of the AAC are its complexity to model and control, in particular the opening procedure of the director switches (DS) since these DS are directly connected in series to the arm inductance. This paper proposes a fast method to control the opening of the DS at zero current. The first part is focused on the instantaneous model and current control of the converter and AAC. The second part is focused on the opening method of the DS without generating overvoltage in the converter and taking into account the technical parameters of the various elements of the AAC. Finally, simulation results validate the DS opening control of the AAC converter.

ID 51

MODELING AND GENERALIZATION OF PARALLEL MULTILEVEL CONVERTER FOR THE DESIGN OF THE CLOSED LOOP'S CONTROLLERS

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Multilevel converters allows to increase voltage, current, frequency without adding weight to the static converter. But those architecture leads generally to the increase of the number of cells, that leads to internals variable that must be controlled as the floating voltage in the serial converters or the differential currents in the parallel converters. This study is focused on the parallel multilevel converters and mainly on the evolution of the differential currents. This paper presents a modelling strategy of a parallel converter depending on the number of legs and the coupling of the legs using three kind of methods. This modelling is then generalized and experimental results are shown to verify the accuracy of the model.

ID 71

ROBUST TUNING OF PID CONTROLLERS FOR TRANSIENT PERFORMANCE

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The automatic voltage regulator system has received much interest in the last decade. Efforts are made to find a parameter set for PID controllers to obtain a fast onset time with minimal overshoot. To assure system stability and robustness, these characteristics must be considered during the optimization process. Cost functions with both time domain and frequency domain specifications with multiple weighting gains have been proposed, requiring a cumbersome task of balancing the weights to obtain satisfactory results. This paper proposes a new performance criterion with stability constraints with only one weighting parameter to set in order to achieve rapid time response characteristics as well as robustness and stability requirements. Its performance is confirmed by comparing its results to those obtained with two previously published performance criteria and the result obtained with systune command in MatlabTM. The results obtained with the proposed performance criterion present a better trade-off between dynamic performance, robustness and stability.

ID 104

FINITE ELEMENT METHOD ANALYSIS OF VARIABLE INDUCTOR FOR DC-DC CONVERTERS IN ELECTRIC VEHICLES

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This paper presents the Finite Element Method (FEM) simulation and analysis of a toroidal Variable Inductor (VI). In systems where there is high dynamics in power demand like Electric Vehicles (EVs), the power inductor is pushed to work in the saturation region several times. In order to overcome this challenge, a current controlled VI is used for the purpose of controlling the saturation level of a power inductor in a bidirectional DC-DC converter for EV applications. Simultaneously, there is an attempt to reduce the size and weight of the power inductors in power converters by using this technology. The studied VI is built with two toroidal cores and is composed of multiple windings, which makes it to have a complex geometry. In addition to its complex geometry, its magnetic properties and non-linear behavior complicate its modeling, analysis and understanding of its behavior. To simplify this and for an easier understanding of its concepts, a simplified mathematical representation of the operation of this device is illustrated and MagNet Simulation software is used for its modeling and analysis.

ID 162

ROBUST MAGNETIC CONTROL OF INTER-CELL-TRANSFORMERS INCLUDING REDUCED NUMBERS OF PHASES OPERATION FOR INTERLEAVED AND PARALLELED CONVERTERS

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Nowadays, parallel multicell converters including inter cell transformers (ICTs) are usually used in many different conversion systems requiring modularity and high current. Basically, classical current feedback control are used to control the output current, based on the modes separation principle. A common mode (CM) which intend to regulate the phase current to obtain the desired performance with an high current sensor and a differential mode (DM), is designed to cancel the difference between the phase's currents using multiple low current sensors. However, for an operation based on a reduced number of active phases this classical control does not allow to balance the flux densities in all cores of the ICT. Cores saturations and current surges through switches can appears. Then, authors propose in this paper another approach based on an innovative magnetic feedback method based on a direct flux density measurement inside the cores' air gap. PLECS simulation shows that the excellent accuracy and great flux densities balanced flowing through the magnetic cores. This solution also offers a significant impact in terms of cost reduction and volume occupied by fully integrated sensors.

Session 1.c

SS Diagnostics & monitoring

ID 26

FINE POWER ALTERNATOR MODELLING FOR DIAGNOSIS PURPOSES BY MEANS OF FLUX2D/MATLAB CO-SIMULATION

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1: LAPLACE, Université de Toulouse; 2: LEROY SOMER

Machine modelling generally rhymes with Park models, also called dq-models. Because of their relative simplicity and their noteworthy efficiency, dq-models are almost always employed when it comes to machine control activities. Their precision in terms of dynamics and output voltage magnitudes makes them valuable to design optimized control architectures. Nevertheless, the signal waveforms within the system could suffer from a noticeable lack of accuracy that may be harmful for diagnosis purposes. By means of simulation results and experimental measurements on a Leroy Somer 27kVA alternator, this paper demonstrates the lack of coherence between signals originating from a power alternator dq-model and measurements from an experimental test bench corresponding to the developed model. For that reason, it will be presented a new methodology of machine modelling considering a co-simulation process between Flux2D and Matlab softwares. Finite elements enable a very fine description of the system inductances, taking into account the geometrical specificities of both the exciter and the main generator, inductances that are then reintroduced in an analytical model developed under Matlab environment. Spectral comparisons demonstrate the validity of this new modelling method.

ID 35

STATISTICAL METHODS FOR THE DIAGNOSIS OF SMALL-SIZE TRAINING SET MODELS. APPLICATION TO THE LIFESPAN MODELLING OF INSULATION MATERIALS

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This paper presents and compares statistical methods for evaluating the performance of parametric model estimation for insulation lifespan in the case of small size training sets. Parametric models are derived from accelerated aging tests on twisted pairs covered with an insulating varnish under different stress constraints (voltage, frequency and temperature). The estimation of the parametric model coefficients requires some hypothesis on the lifespan statistical distribution. However, since the number of measurements for each configuration is constrained by the experimental cost, the results given by classical goodness-to-fit tests and graphical tools may be questionable. This paper thus proposes to use the bootstrap technique for a more thorough statistical analysis. Indeed, bootstrap has been specifically designed to infer the statistical properties of an estimator when only few observations are available. In our case of study, the bootstrap technique confirms the results obtained using graphical tools and goodness-to-fit tests and thus the adequacy of the underlying statistical hypothesis required for model parameter estimation.

ID 99

MEMS WIRELESS VIBRATION MONITORING OF ELECTRICAL ACTUATORS

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In this paper a wireless dispositive for vibration monitoring in electrical actuators system is proposed. The sensor node is composed essentially on MEMS accelerometers sensor and an ESP8266 RF emitter. The proposed solution will illustrate and its advantage related to other wired one will be highlighted. A Human Machine Interface (HMI) has been settled in LABVIEW software to analyse results and to facilitate user intervention.

ID 137

DETECTION OF STATOR FAULT IN SYNCHRONOUS GENERATOR WITHOUT THE KNOWLEDGE OF THE HEALTHY STATE

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This paper focuses on the detection of inter-turn short circuits which can appear in the stator windings of a salient pole synchronous generator. A diagnosis method based on two external flux sensors is developed. In faulty case, it is shown that variations of reactive power leads to specific variation of sensitive spectral lines in the signals delivered by both sensors. This property allows one to define a diagnostic procedure which does not require the knowledge of the healthy state

ID 161

ESTIMATION OF PISTON FLOW PARAMETERS IN AN AXIAL PISTON PUMP USING THE VOLD-KALMAN FILTER

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Axial piston pump is a key component widely used in hydraulic systems. Many researchers were interested in its condition monitoring through signal processing techniques. A fault apparition will lead to direct consequences on the pump performance depending on its severity. To ensure an efficient preventive maintenance for such a machine, it's important to implement fault detection techniques able to provide precise information about the faulty component. This will lead to increase the useful life of the unit and save important maintenance costs.
The pump components mostly susceptible to be affected by a wear are : (the barrel, the valve plate, the slipper...). The most sensitive component is the piston. Its wear can provoke significant internal leakage and affect the output flow signal. This paper investigates the piston leakage using the output flow signal which is composed of all pistons positive flow. The so-called Vold-Kalman filter commonly used in order tracking of bearing signals is implemented to estimate piston flow parameters.
A model based on Simscape software was implemented to achieve realistic simulations. The aforementioned outcome signals are used to show the efficiency of the estimation method and its ability to detect the faulty piston.

ID 163

Assessment of Different Techniques for the Diagnosis of Rotor Magnet Demagnetization in Five-Phase Surface Mounted Permanent Magnet Generators Drive

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Multiphase permanent magnet generators are becoming attractive alternative for a variety of industry applications. In this context, diagnosing the status of the rotor magnets is necessary to guaranty the required efficiency of the generators. This paper deals with different techniques that can be adopted for quantifying the level of rotor demagnetization in closed-loop controlled five-phase permanent magnet generator. More specifically, a field oriented control scheme is investigated to identify the control impact on magnet demagnetization detectability based on voltage and current signature analysis. It will be shown that the last approach has the advantage of being less dependent on the operating point of the generator. The proposed comparative study is analytically established, and validated by means of numerical simulations thereby.

Session 2.a

SS Modeling and Control of Advanced Power Electronics for Renewable Energy and Power Quality

ID 22

GRID TIE INDIRECT MATRIX CONVERTER OPERATING WITH UNITY POWER FACTOR UNDER DOUBLE SPACE VECTOR MODULATION

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The present paper examines the architecture of the indirect matrix converters when controlled under double space vector modulation technique (DSVPWM). The applied modulation proves high standards and provocative results in terms of achieving a unity input power factor. Satisfactory signals' waveforms from both sides of the topology are exhibited along with their detailed harmonic analysis.

ID 121

Modulation technique highlight for state of charge balancing on a series cascaded converter

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This paper describes and compares two different methods of active state-of-charge (SoC) balancing on a grid-tied series cascaded H-bridge converter with splitted energy storage system. These SoC balancing techniques are based on two different modulation behaviour and do not require any extra component. Power balancing is mandatory due to the disparity of State of Health (SoH) and initial SoC that are expected. After a short presentation of the power conversion and energy storage system, with its major sizing constraints, the focus is made on optimizing energy storage, with little compromises on system reliability, availability and efficiency. The influence of power balancing techniques on the total harmonic distortion on the grid side is discussed, as well as the total stored energy, which is influenced by total efficiency and maximum total SoC reached.

ID 128

Direct Control for Active Power in three-phase application on perturbed network

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There are today many techniques for controlling active filters on three-phase networks in order to correct the power factor and limit the harmonics consumed at the source. Almost all of these methods are designed for a perfect sinusoidal source and don't perform sinusoidal current when voltages are perturbed. The work developed here concerns the active filtering on a perturbed network, that is to say the presence of voltage harmonics at the connection point in addition to an unbalanced voltages system. A proposed method is described and their results are compared to those obtained by the p-q theory, modified p-q theory and p-q-r method for an application on a three wire power distribution network under perturbed voltage and non-linear load. The assessment concerns the system of currents in the source side after filtering and a comparative evaluation for unbalance factor and THD for all methods.

ID 133

Reactive Power Ancillary Service by a Three-Phase PWM Rectifier with Optimal DC-Link Voltage Selection

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Reactive power compensation in the proximity of loads is beneficial for the overall efficiency of distributed AC systems. The reactive power can be supplied from either passive elements (like capacitor banks) or active elements (like static VAR generators). Extra use of reactive power suppliers can be avoided by providing reactive power through loads themselves. This is particularly the case of loads connected to the grid through PWM rectifiers that have the potential for providing reactive power to others local loads. This paper investigates first the reactive power ancillary service by a three-phase PWM rectifier. Then, a detailed analyze is presented for the selection of the optimal dc-link voltage level when the PWM rectifier supply local loads with reactive power. Finally, the control of a PWM rectifier with an ancillary function of reactive power compensation and with an optimal dc-link voltage selection is detailed. Experimental results are presented to confirm the validity of the proposed control strategy.

ID 150

Equivalent Circuit Model of a Synchronous Generator for Grid-interfaced Inverters

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Distributed power generation gains more importance since 1990s. Nevertheless, researches have already revealed that a high penetration of renewable energy sources is detrimental to the grid stability due to the lack of inertia and the control of a power converter. To have the least impact on the utility, a converter is suggested act as a synchronous generator (SG), called virtual synchronous generator (VSG). Although a model for a SG was well-established decades ago, the first equivalent circuit modeled in a converter way was proposed in 2015. The converter-like model provides people better understanding when they implement a VSG. However, to compare with a power converter, the model made assumptions that scarifies some machine properties. To fully analyze the interaction among converters, SGs, and the grid, a model with greater details is required. In this paper, a complete mechanical-to-electric equivalent circuit of a SG is proposed and a measurement from a 28-kW SG was conducted to verify the proposed model.

ID 151

A numerical optimization method using the simplex algorithm for control of modular multilevel converters

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The paper proposes an optimization formulation of the control problem for modular multilevel converter. The control problem is solved by using a numerical method based on the simplex algorithm. The method is evaluated in simulation and compared to existing control strategies, with consideration being given to the linearity range and total harmonic distortion.

Session 2.b

Control methods for electric machines

ID 40

Real-Time Validation of a Cascaded Model Predictive Control Technique for a Five-Phase Permanent Magnet Synchronous Machine Under Current and Voltage Limits

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Multiphase machines have recently gained importance in the research community for their use in applications where high power density, wide speed range and fault-tolerant capabilities are needed. The optimal control of such drives requires to consider voltage and current constraints imposed by the power converter and the machine itself. If classical three-phase drives have been optimally controlled under such limits for a long time, the same cannot be said in the case of multiphase drives. This paper deals with this issue, where an optimal control technique based on Cascaded Model Predictive Controls (MPC) is presented for a five-phase permanent magnet synchronous machine (PMSM). A Continuous-Control-Set MPC (CCS-MPC) numerically computes optimal current references in real-time in order to exploit the maximum performance for given DC bus voltage and current limits. Then, a Finite-Control-Set MPC (FCS-MPC) is used to carry out the current control in the machine, directly applying the switching state that minimizes a cost function related to the current tracking. Obtained mixed microprocessor-based and FPGA-based real-time simulations prove the interest of the proposal, which ensures the optimal control of the multiphase drive operating under current and voltage constraints

ID 45

SYNTHESIS AND PRACTICAL IMPLEMENTATION OF INTEGRATED CONTROL SYSTEM FOR FRESHWATER PRODUCTION UNIT FED BY RENEWABLE SOURCE WITHOUT BATTERY

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1: ENIT, Tunisia; 2: ESIER, Tunisia; 3: ENSIT, Tunisia

In this paper we present an integrated control strategy elaborated to manage electrical power transfer for desalination system coupled to hybrid source (PV-Wind) via DC bus without using electrochemical storage. The power control strategy adopted allows simultaneously to maintain DC bus voltage stability and to control electrical power flow transferred from the source to motor-pumps used for water pumping and/or reverse osmosis desalination. Experimental results issued from the implementation of the control are demonstrated and discussed to evaluate power sharing performance and ""Water-Energy"" cooperative control effectiveness.

ID 64

Position Control Scheme for a Commercial Motor

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University of the Basque Country, Spain

In this work a robust position control scheme for a commercial induction motor is developed. The controller is designed using the sliding mode control theory and provides a high performance for a real time applications. The proposed control scheme incorporates a sliding mode rotor flux and load torque estimator to avoid the flux sensors and in order to improve the control performance. The computational cost of this control scheme is low, and therefore it is adequate to be implemented over a low cost Digital Signal Processor (DSP).

ID 105

EVOLUTION OF POWER AND LOSSES IN PERMANENT MAGNET SYNCHRONOUS GENERATORS USING NON-LINEAR POWER CONVERSION SYSTEM NAMED MERS (MAGNETIC ENERGY RECOVERY SWITCH)

Morel, Simon Florent Arthur; Garbuio, Lauric; Gerbaud, Laurent; Lefranc, Pierre

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The paper deals with the strengths and weaknesses of the combination between a Permanent Magnet Synchronous Generator connected with a non-linear power conversion system named MERS (Magnetic Energy Recovery Switch). An analytical coupled model of a PMSG connected with a MERS is introduced and allows the calculation of the evolution of output power and losses for different operating points. A focus on the iron losses induced by the MERS in the generator is given. Thus, the dependencies of the efficiency and power-to-mass ratio according to operating points of the generator and MERS show that this solution is more appropriated for specific application. So, a comparison of the power capacity increased and the evolution of the efficiency and a description of the application where the MERS is relevant is presented at the end of the paper.

ID 117

Vector Control of a Standalone Cascaded Doubly Fed Induction Generator Feeding Unbalanced Loads

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This paper addresses the imbalance issue of a standalone CDFIG supplying unbalanced three-phase load. Under this operating condition, the output stator voltage will be unbalanced due to the load effect. A compensation method dealing with dual rotating frames is proposed to balance the output voltage by means of PI controllers. The positive and the negative sequence components of the machine quantities are controlled respectively in the positive and the negative rotating frames. Simulation results attest of the ability of the controller to compensate the voltage imbalance and reject the unbalanced load impact on the generated voltages.

ID 141

Comparison of Current Control Strategies for Medium Power High-Speed PMSM

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The interest for high-speed machines has been growing in industry, due to their advantages of high power density and dynamic. However, the control still represents a difficult issue. With increasing speed, the ratio of fundamental frequency to sampling frequency is rising, which requires high bandwidth and high dynamic current response. This paper presents an overview about the problems of controlling high-speed machines and an analysis of current control strategies for high-speed permanent magnet synchronous motors (PMSM). Three different control schemes are analyzed, the Discrete-Time PI control, the Deadbeat Control, and the Dahlin Control and evaluated based on stability, robustness, dynamic and steady-state performance.

Session 2.c

Diagnostics & control for wind power applications

ID 10

COMPARATIVE STUDY OF TWO ROBUST CONTROL STRATEGIES APPLIED ON A WIND CONVERSION SYSTEM BASED ON A HYBRID EXCITATION SYNCHRONOUS GENERATOR

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This paper deals with a Wind Conversion System (WCS) based on a Hybrid Excitation Synchronous Generator (HESG) connected to an isolated load modelled under Matlab/Simulink. To ensure an efficient and reliable use of a wind power generation system, a tight control remains vital. In fact, the dynamic equations of a turbine are strongly nonlinear as are the ones of a HESG, most of the system parameters are highly uncertain, and, at last, a WCS is always affected by unknown disturbance sources. To address these problems, robust control methods must be adopted. In this paper, two control strategies for the improvement of the wind turbine extracted power are investigated. First, a H∞ controller is implemented. Then a second-generation CRONE controller is designed. The performance of the two controllers in the tracking of the optimal power outputs and the robustness to parameters' uncertainty are compared.

ID 28

EXPERIMENTAL VALIDATION OF MECHANICAL SENSOR FAULT DIAGNOSIS AND FAULT-TOLERANT CONTROL FOR WIND TURBINE

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Faults in engineering systems are difficult to avoid and may result in serious consequences. Recently, wind energy has achieved prominence in renewable energy production. Therefore it is necessary to develop a diagnosis system and fault-tolerant control to protect the system and to prevent unscheduled shutdown. The present study aims to provide an experimental analysis of position sensor fault-tolerant control for a wind turbine system based on permanent magnet synchronous generator (PMSG) using a sliding mode observer and backstepping controller system to avoid any deterioration caused by sensor fault. The control algorithm is implemented using dSpace 1104 device. The experimental results have been verified and have validated the effectiveness of the proposed method.

ID 32

OPTIMAL TECHNO-ECONOMICAL STORAGE SIZING FOR WIND POWER PRODUCERS IN DAY-AHEAD MARKETS FOR ISLAND NETWORKS

Hernandez Torres, David; Turpin, Christophe; Roboam, Xavier; Sareni, Bruno

LAPLACE / Université de Toulouse, France

In this article an optimal storage sizing based on technical and economical modeling is presented. A focus is made on wind power producers participating in day-ahead markets for island networks. The modeling approach is based on power flow models and detailed optimization-oriented techniques. An importance is given to the storage device ageing effects on the overall hybrid system levelized cost of the energy. The results are presented for the special case of renewable power integration in the French islands networks. The analysis obtained after the results shows the importance of this type of modeling tool for decision making during the initial conceptual design level.

ID 49

Normal functioning of a Wind turbine based on coupled electromechanical dynamic model - The DFIG case

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The ever increasing demand for energy around the world has made wind energy a forerunner in eco-friendly energy production. There have been many types of Wind Turbines (WT) from the 90’s till this date and they are briefly explained here. In this paper, a DFIG Wind energy generation system is completely modeled using MATLAB Simulink and Simscape drivetrain and Fluid libraries that allow the modeling of mechanical and electrical systems in one environment. A simulation in normal operation is done on the finalized model to study its behavior for varying wind speeds.

ID 63

INTEGRATING A SERIES PARALLEL OFFSHORE WIND FARM INTO A MULTI-TERMINAL DC GRID AND COORDINATED CONTROL SCHEME

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This paper presents a Multilevel Modular Converter (MMC) based Multi-terminal DC (MTDC) grid which includes a DC Series Parallel (DCSP) offshore wind farm. This wind farm topology allows interconnection of wind turbines with the need of neither centralized converter nor bulky platform at the offshore end. However, the coupling behaviour of series connected wind turbines operating in uneven wind conditions can cause some units to operate in overvoltage, and thus requires the curtailment of wind power capture. To reduce the undesired curtailment of wind power, this work proposes a control strategy to regulate the HVDC voltage to ensure sound operation of each wind turbine. This control strategy can be extended to a MTDC system. The control strategy has been conducted and validated on a 4-port MTDC system developed in EMTP-RV. It is concluded that the MMC-MTDC system including a DC series parallel offshore wind farm is stable and can be operate at maximum wind power capture by the proposed control strategy.

ID 119

SCALING OF WIND ENERGY CONVERSION SYSTEM

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This paper presents a scaling methodology based on dimensional analysis and applicable to systems' mathematical models. The main goal of this research is to propose time-compressed HIL experiments together with reduced power, while keeping similarity with respect to the dynamics of the original system. The scaling process is presented using a simple wind turbine model. This reduced model is validated through a simulation in which the wind conversion system is connected to a scaled electrochemical battery.

Session 3.a

SS Modelling And Tools for Power Converters Design

ID 79

Modelling and design approaches for the preliminary design of power electronic converters

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This paper presents different modelling approaches and design tools, initially developed for the preliminary design of mechatronic system, and applied here to power electronic converters. This approach, which requires different type of models for components and system level, is illustrated on the design and optimization of a DC/DC converter. A dedicated framework is used to manipulate and associate the models.

ID 82

SELECTIVITY IN FREQUENCY MODELLING OF ELECTRICAL CIRCUIT FOR THE SIZING BY OPTIMIZATION OF EMC FILTER FOR POWER ELECTRONICS

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The paper deals with the frequency modelling of EMC phenomena using equivalent circuit (with frequency perturbation sources for the modelling of the switching cells of the static converters) in the context of the sizing by optimization of EMC filter. The paper focusses on the way to obtained automatically a frequency model, including the exact computation of its jacobian, useful in the context of design by deterministic gradient optimization. It mainly focuses on selectivity (optimization contextualization) in the modelling with its interests compared to genericity in the use by a gradient optimization algorithm. The approach is applied to optimization of EMC filter for power electronics aircraft context

ID 129

DESIGN BY OPTIMIZATION OF A THREE PHASES AFE UNDER EMC CONSTRAINTS

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This paper compares a step by step design of a power electronics converter with the results obtained using a design by optimization technique, solving all equations together. “Order one” method is privileged, in order to facilitate seeking a design optimum in a very constrained space of solutions (especially due to Electromagnetic Compatibility). Specific derivable models for each constraint and component design have been used. Difficulties of these derivable formulations are underlined, as well as the effectiveness of the method in comparison with the conventional step by step approach, especially regarding EMC.

ID 147

OpenComp3d: A Description Framework Dedicated To Design Components of Power Electronics

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LAPLACE, Université de Toulouse, France

This paper is an overview of an innovative optimization framework – available under free licence - developed for the automatic design of components of power converters. In the first part, the general principles, structure and standards are presented. In the second part, an example is performed to optimize the output inductor of a buck converter showing the advantages of the proposed methodology.

ID 157

DEVELOPMENT OF BOOST INVERTER SYSML MODEL FOR HARDWARE-IN-THE-LOOP SIMULATIONS

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The boost inverter is a topology which provides both boosting and inversion in a single stage from DC sources. This structure has been usually studied in literature for design, implementation, and control perspectives; however, its modeling and implementation in Hardware-in-the-Loop simulations has been less widespread. In this context, this paper presents an innovative modeling methodology based on the Systems Modeling Language (SysML) intended to implement the boost inverter model in Hardware-in-the-Loop real-time simulations. The proposed modeling approach uncouples the boost inverter system in functional components which allows a detailed study of each component for more accurate results and model adaptability. The proposed methodology is able to transform the model descriptions from SysML to the High Level Specification of Embedded Systems (HiLeS) for automatic code generation and model implementation in FPGA. Finally, results from boost inverter model implemented in FPGA are compared with experimental results with suitable trade-off between accuracy and execution time for Hardware-in-the-Loop simulations.

Session 3.b

SS EMR and Other Graphic Descriptions. Application to EVs and HEVs

ID 18

STUDY OF HYBRID RAILWAY POWER SUBSTATION TO REDUCE ELECTRICITY BILL

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1: SNCF Innovation & Research, France; 2: EDF R&D, France

To respond to the growth of passenger flow in railway transportation, the increased frequency of trains makes the railway power substation reach its power capacity. In the framework of the partnership project between SNCF and EDF Concept Grid, this paper investigates the modeling and control of hybrid railway power substation to reduce the electricity bill, especially public electric grid usage cost. The Energetic Macroscopic Representation (EMR) is adopted to represent the hybrid system and conceive the corresponding control. The case study at the railway power substation Sarry reveals that around 9% of the electricity bill can be reduced with the proposed hybridization.

ID 66

Diesel-Electric Excursion Ships Enhancement using Energetic Macroscopic Representation

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This paper presents a modelling approach using Energetic Macroscopic Representation (EMR) to study the enhancement of a diesel-electric excursion ship by a series hybrid configuration using supercapacitors. As the regenerative braking is not possible, the challenge depends on the correct integration of subsystems within an improved strategy that continuously monitors and balances the energy flow onboard the ship. First, a base-model of a diesel-electric ship is approached using EMR and its inversion-based control scheme is directly deduced. The propulsion model is based on the electric power demand profile on a real mission of 15 min. After, on this model, a new one is developed to integrate SuperCapacitors (SCs) on the DC bus by a semi-active topology. A global control strategy is proposed to coordinate the ICE-generator and SCs systems to keep constant the DC bus voltage. Two approaches are studied: one with the actual ICE (200 Hp) and other with a possible downsized ICE (90 Hp). A consumption and CO2 emission comparison is made for three configurations. The results show that it is possible to reduce consumption for diesel-electric excursion ships: the series hybrid configuration with downsized ICE can reduce by 9.6% the consumption.

ID 101

ENERGETIC MACROSCOPIC REPRESENTATION AND CONTROL OF A CVT-BASED MEDIUM-DUTY HYBRID ELECTRIC TRUCK

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A medium-duty parallel Hybrid Electric Truck (HET) with Continuous Variable Transmission (CVT) is studied. The Energy Management Strategy (EMS) can be improved using a CVT compare to a classical gearbox because a new degree of freedom is introduced. However, the control and EMS is more complex. The Energetic Macroscopic Representation (EMR) is used to organize the model and deduce the control. A rules-based EMS is defined. Simulation results are provided.

ID 109

ENERGETIC MACROSCOPIC REPRESENTATION OF HYBRID AND ELECTRIC PROPULSIONS IN SHIPS

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1: Ecole Navale IRENav; 2: Segula Technologies, France; 3: Universite de lorraine; 4: University of Lille1, L2EP, Lille, France

This paper deals with the energetic macroscopic representation (EMR) of hybrid and electric propulsions of ships. A multidisciplinary model is proposed for a series hybrid ship. The studied hybrid system model includes the main source (generator), an Energy Storage System (ESS) which is used as secondary source (batteries in our case), a complete model of the boat (propeller, hull). The model of the global system is organized using the EMR.

ID 152

Embedded Real-Time Simulator Implementations of Electromechanical Systems Using System-On-Chip Devices

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This paper studies the suitability of System-on-Chip (SoC) devices to perform embedded Real-Time Simulators (RTS). These new devices combine powerful general purpose processors, a Field-Programmable Gate Array (FPGA) and other peripherals which make them very convenient for controlling and monitoring a complete system. A Doubly-Fed Induction Generator (DFIG) has been chosen to evaluate the device in terms of computational power, area utilisation and precision. Moreover, it is also investigated whether a system of these characteristics is interesting to be running as a hardware accelerator. Different data transfer options between the Processor System (PS) and the Programmable Logic (PL) have been studied as well for this matter.

Session 3.c

SS Optimized Control and Modeling of Electric Machines

ID 13

ANALYSIS AND MINIMIZATION OF TORQUE RIPPLE IN SYNCHRONOUS RELUCTANCE MACHINE BY SUPPLYING NON-SINUSOIDAL CURRENTS

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The torque ripple limits the performances of synchronous reluctance machine (SynRM). In considering the structure feature of SynRM, this paper applies a general torque expression to calculate optimal currents which are not sinusoidal and are used to reduce torque ripple. Besides, the compensated torques by supplying different orders of optimal currents harmonics are also compared and analyzed and several suggestions are presented. At last, simulation performed in Flux 2D confirms the effectiveness of the optimal currents obtained by the above method.

ID 31

IMPACT OF THE INTERMITTENT CONTROL ON THE VIBRATION BEHAVIOR OF A SWITCHED RELUCTANCE MACHINEMachine

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The aim of the intermittent control is to increase the global efficiency of Switched Reluctance Machine (SRM) and its power converter in the case of electric vehicle application. However, the SRM is characterized by vibro-acoustic noise which needs to be studied. This paper analyses the vibratory impact of the intermittent control on the SRM and proposes different sliding strategies of the intermittent control to reduce this impact. This is done by analyzing the radial forces, the total accelerations applied on stator teeth and their harmonic contents given by a simplified electromagnetic-mechanical vibratory model of the SRM.

ID 52

OPTIMAL CONTROL STRATEGY OF SWITCHED RELUCTANCE GENERATOR

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GeePs, France

This paper presents a high efficiency strategy to control a Switched Reluctance Generator (SRG) for wind energy application. The analysis of the electromechanical energy conversion including all the losses both in the machine (electrical, magnetic, mechanical) and the power converter (switching and conduction losses), has shown that there is an optimal combination of the control variables (excitation voltage, turn on and conduction angles, reference current) to maximize the efficiency. By combining Finite Element Analysis and optimisation algorithm, the main control parameters (turn on and conduction angles) are obtained for all the operating points in the torque-speed plane. Thanks to the smoothness of their variation, polynomials can be used instead of lookup tables to implement the optimized angles in the control scheme. The strategy is evaluated using numerical simulations of an 8/6 SRG feeding a resistive load. The results show good performances of the output DC voltage control even in presence of speed and load variations. Thanks to the optimisation, the global efficiency increases with the speed and reaches 70% almost from half the nominal speed to the maximum speed.

ID 84

Finite elements-based control dedicated to a permanent magnet synchronous machine

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In this paper, a dynamical model of a Permanent Magnet Synchronous Machine (PMSM) adapted to the design of a torque/speed controller is proposed. It is not based on classical assumptions leading to equations in a synchronous dq-reference frame. Indeed, in most cases, a so-called “Park model” requires magnetic linearity and spatially-sinusoidal magnetomotive forces. Since these two properties are not satisfied in pratice, this model can be adapted but a more rigrous approach is followed here. It is based on Finite Elements Analysis (FEA) results and then, dynamical equations are derived and used to propose a controller scheme based on an inverse model. Simulation results are finally discussed.

ID 106

Scalar Control Optimization Technique Taking into Account Core Losses for an Induction Motor

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Control systems constitute a main part of energy efficiency studies on electric motors, where efficiency varies according to the operating point and the mechanical load of the motor. The purpose of this paper is to present an optimization technique to the classic scalar control of the squirrel-cage induction motor (IM), aiming to improve its energy efficiency while taking into consideration the effect of the core losses in the motor. A table defining the best efficiency flux reference is computed, based on an improved model of the IM including core losses. It gives the necessary stator flux reference for the scalar control system according to the operating point, in order to get the best efficiency and the lowest possible losses. Simulation results validate the proposed optimized scalar control and show the improved energy efficiency as well as a reduction in power losses.

Session 4.a

SS Hybrid Energy Storage Systems (H-ESSs) for Vehicular Application

ID 98

ENERGY MANAGEMENT OF HYBRID ENERGY STORAGE SYSTEMS FOR ELECTRIC VEHICLES: A MULTI-OBJECTIVE APPROACH

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Using supercapacitors (SCs) to configure the hybrid energy storage system (H-ESS) to extend batteries life–time is promising for electric vehicles (EVs). Energy management strategy (EMS) is mandatory for such systems. Most of previous works develop improved EMS with only one objective (batteries life–time). However, at least the costs on SCs operation also could be considered. Generally, a methodology to develop multi-objective EMS is demanded. This paper presents a procedure to develop multi-objective EMS of H-ESS for an EV. SCs system losses are considered as the second cost function. Dynamic programming is used to give the benchmark to evaluate the performance of the other strategies. Simulation results validate the effectiveness of the developed off-line EMS. The dynamic programming generates a Pareto front to be used in order to compare with another on-line EMS.

ID 116

Comparison of two battery/Supercapacitors architectures for electric vehicle

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Batteries have been associated with supercapacitors in some vehicle applications. This has been done to face the batteries limitations in terms of power transfers and lifetime. This paper deals with a comparison between two battery/supercapacitors architectures. The first architecture consists in using a DC-DC converter as an interface for the supercapacitors. In the second architecture two DC-DC converters are used, one for each source. The energy management of the two architectures is first performed. The two architectures are then compared by simulation tests on a normalized driving cycle. The results show that the performances are equivalent in terms of battery lifetime.

ID 132

An improved Frequency Sharing Strategy Between Battery and Supercapacitors in Electric Vehicles

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Optimal power management policy improves lifetime and compensate added extra-cost of hybrid electrical storage systems which combines batteries and supercapacitors. In this paper, best use of the complementarity between batteries and supercapacitors in electric vehicles is studied. First Storage devices are sized based on reduced size specifications of the electric vehicle. Then, frequency sharing strategy is presented. Power waveforms for each storage device obtained by simulation showing promise for giving superior improvements. Various values of cut-off frequency are scanned to analyse the variation effect of power sharing strategy on battery current waveforms. The optimal filter configuration (cut-off frequency) is finally determined to reduce values of RMS battery current and enhances of battery service life

Session 4.b

Fuel Cells

ID 67

ENERGY MANAGEMENT OF A MICROGRID WITH HYDROGEN STORAGE AND MULTI FUEL CELL SYSTEM

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This paper presents a power sharing for a DC microgrid (MG) system, which is operated in islanded mode. The DC MG includes renewable energy production and energy storage. A wind turbine and a Photovoltaic (PV) array are considered as the main sources. Two energy storage systems, battery and hydrogen, are proposed in this study in order to support the balance between load demand and energy generation. The hydrogen loop includes an electrolyser (EL), hydrogen storage and a multi fuel cell (FC) system. Compared with single FC, the multi-FC system can improve the reliability and the efficiency of the system. Furthermore, the multi-FC system is more redundant and flexible in a wide range of MG applications. Regarding the energy distribution, three power splitting algorithms have been studied and employed for multi-FC system. The simulation stage has been conducted for two scenarios of power sharing between battery and FC system. The simulation outcomes clearly indicate the appropriateness of the proposed method for achieving the best FCs operation.

ID 102

Analysis and Modeling of the performance degradation dynamics of a H2/O2 PEM Fuel Cell stack under constant current solicitation

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1: University of Toulouse ; INPT, UPS ; LAPLACE (Laboratoire Plasma et Conversion d'Energie) ; ENSEEIHT; 2: CNRS ; LAPLACE; 3: Areva Energy Storage

In this article, the analysis of an ageing campaign under a constant current solicitation on a H2/O2 PEM Fuel Cell stack for the synthesis of an ageing model is presented. A first part presents briefly a state of the art of the degradation modes and mechanisms existing in PEM fuel cells and of the approaches to model them. The evolution of the losses through time experienced during the campaign is then scanned in turns at the stack scale and at the stack's cells scale. Characteristic features of the stack voltage evolution over time are afterwards extracted and analyzed while the dependence of the performance decrease to the running time and to the time positions of the start/stop phases is explicitly emphasized. Finally, a synthesis of the study is proposed with a first level of modeling for the stack ageing.

ID 114

Determination of Mechanical Tightening of a PEM Single Cell via Electrical Measurements (Application in Aircraft)

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Fuel Cells on board aircraft can be submitted to severe levels of vibration that can potentially cause gradual or abrupt assembly decompression, leading to hydrogen gas leakage. The electronic part (Re-) of the total cell resistance (Rtot) is susceptible to the variation of assembly clamping pressure, what in theory makes it a direct indicator of the quality of mechanical tightening. However, Re- is not accessible by standard on-line measurement techniques. In this work, we are studying the possibility of extracting Re- from the measurable Rtot of a commercial, single cell with a conventional measurement method. The main obstacle is that, in nominal conditions, Re- is not easily extractable because its value is negligible in comparison to the other component of Rtot, i.e. the protonic resistance of the membrane and ionomer (RH+). A theoretical study has been conducted to process the separation of RH+ and Re-, based on their mathematical modelling in the function of temperature. The laws that dictate the evolution of RH+ and Re- with temperature are different in nature and it is possible to separate them and thus to assess Re-. An experimental phase is being conducted in order to confront the model and its hypotheses with the real world.

Session 5.a

SS High Voltages, Plasmas and Pulsed Power Applications

ID 65

DESIGN AND ELECTRICAL SIMULATIONS OF A RESONANT TRANSFORMER IN A 200 KHZ DC-DC CONVERTER FOR PULSED POWER APPLICATIONS

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1: Laboratoire SIAME, France; 2: EFFITECH, France

Nowadays, high pulsed power applications need to make compact modulators able to generate pulses in the MW range with long duration of many microseconds. These modulators should be able to address many civilian and military applications, improving efficiency and performances. This improvement requires the development of innovative structures aiming at producing both average and peak powers and whose interest is significant at the application level. A solution can be to use technologies based on solid state switches combined with transformers and resonant circuits. These systems allow for the making resonant converters (in the case described in this paper the topology used is a LCC configuration). Resonant converters are commonly used for DC applications or with low repetition rate but they can also be useful for high power applications. This paper deals with the design of the transformer in the case of a 200kHz DC-DC converter able to generate square pulses in the range of 1 MW peak power with a duration of 100µs and a repetition rate of 100Hz. The design is explained with the theoretical calculations of the transformer and the results of associated electrical simulations are presented.

ID 103

Excimer lamp for dermatology equipped with UV dose control

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Spectral range of UVB is widely used for treating psoriasis and vitiligo. Portable and low-cost XeCl excimer lamps having the 308-nm wavelength are more suitable for dermatology than traditional excimer lasers. Unlike laser, excimer lamps have a significantly decreased radiation intensity which depends on the distance to the treated skin area. The authors explore a new prototype for skin treatment having an automated UV dose control system. The system makes measurements of the distance to the treated area of the skin and calculates the treatment time according to the required UV dose. If the distance is changed during the phototherapy, the control system corrects the treatment time in the online mode. The article describes other functional opportunities of the control system.

ID 115

ADVANCED ANALYSIS OF TRANSIENT OVERVOLTAGE IN ELECTROMECHANICAL CHAIN FED BY SIC INVERTER

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1: IRT Saint Exupery; 2: LAPLACE

Key areas in the development of More Electrical Aircraft (MEA) are, currently, DC power distribution in higher voltage levels and the use of disruptive technology such as Wide BandGap (WBG) semiconductor. Using WBG components (SiC and GaN) increases the power converter mass density. However, fast switching of WBG components (tens of kV/µs) induces voltage transient overshoots due to parasitic coupling within the inverter. In addition, propagation and reflection phenomena along the harness, even for small lengths, cause voltage overshoots across the loads. Such overvoltage in an electromechanical chain (association of inverter, harness and motor) supplied by the new HVDC 540V aeronautical network could be fatal for the Electrical Insulation System (EIS). This paper proposes an accurate and fast model to predict overvoltage along a harness; it allows to analyze the impact of SiC inverter output voltage waveforms.

ID 146

DESIGN OF A POWER SUPPLY CAPABLE OF DRIVING A DIVERSE SET OF DBD EXCILAMPS

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1: Pontificia Universidad Javeriana, Colombia; 2: Institut National Polytechnique de Toulouse, France; 3: Universidad Sergio Arboleda, Colombia

In this work the procedure to design a power supply capable of supplying nineteen different exciplex Dielectric Barrier Discharge (DBD) UV lamps, is shown. This power supply is conceived with the aim to study the impact of the DBD lamp geometrical characteristics over their performance. The pulsed power supply can sweep parametrically three electric parameters: frequency, amplitude and duration of the current pulses. For this reason, a wide operating range is needed and the choice of the elements for the power supply is a challenge. Modeling of the lamps is employed to define the most interesting operating points to be explored and also used for the selection of the switches ratings and the transformer turns ratio.

Session 5.b

Fuel Cells & storage systems

ID 94

MODELING AND OPTIMAL ENERGY CONTROL OF A FUEL CELL ELECTRIC SCOOTER

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GeePs, France

The energy management of a hybrid fuel cell / supercapacitor system is studied, both in simulation and on a test bench, for experimental validation. This system can be used to power a urban electric scooter. Two off-line energy management strategies are implemented and compared to control the power split between the fuel cell and the supercapacitor: Pontryaguine minimum principle (PMP) and dynamic programming. In the case of PMP, time evolution of the co-state is accounted for, and operational constraints on the supercapacitor state of charge are included. Simulation and experimental results agree very well, which validates the system model and the implementation of the control strategies on the real system. This work will be used as a basis to develop online strategies.

ID 100

TIME CONSTANT BASED METHOD FOR PEM FUEL CELL MODEL CHARACTERIZATION

EL AABID, Sami; REGNIER, Jérémi; RALLIERES, Olivier; TURPIN, Christophe; GAGER, Guillaume; DARBIGNY, Julien; HORDE, Theophile; PRISSE, Lucien

IRT Saint Exupéry, Laplace laboratory

The aim of this paper is to develop an identification tool based on electrical circuit approach to contribute to the fuel cell characterization. Considering generic RC cells in series models, an identification process fed by experimental data allows to find the model parameters describing the dynamic of the phenomena involved in the fuel cell operation. The proposed model is built through specific physicochemical laws, such as activation or diffusion, and allows a distinction between the different phenomena. A constant-time spectrum is extracted from the identified model and analysed to underline the method sensitivity to failures. Experiments are achieved to confirm the potentiality of this characterisation method, they proved that such a perspective can offer further information to investigate the monitoring of the state of health and the aging of fuel cells.

ID 125

Characterization and modelling of a commercially available high temperature PBI-H3PO4 based membrane electrode assembly in various operating conditions

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A commercially available High Temperature (HT) Membrane Electrode Assembly (MEA) using a phosphoric acid doped PolyBenzImidazole (PBI) membrane was tested in various operating conditions according to a design of experiments of three factors varying on three levels: hydrogen gas stoichiometry (1.05, 1.2, 1.35), air gas stoichiometry (1.5, 2, 2.5) and temperature (140°C, 160°C, 180°C). Polarization curves were performed at each operating conditions (27 curves in total) including 22 current stages. A semi-empirical, one-dimensional, isothermal and steady-state model of the cell voltage was developed in order to fit experimental data using only one set of parameters (simultaneous optimization of 27 curves). The number of model parameters was reduced according to physical interpretation of experimental observations. The average error of the model is less than 0.85 % and the maximum error is around 3.6% between modelled and measured voltage. The obtained parameters seem to be consistent, according to the different operating conditions tested. The feasibility of performing fractional design of experiments was also investigated. As a conclusion, the simultaneous optimisation of the model on all the experimental curves with only one set of parameter seems to be an interesting approach in order to get closer to parameter uniqueness and consistency.

ID 127

A DIRECT SIZING METHOD AND SPECIFIC CHARACTERIZATION OF ENERGY STORAGE DEVICES/SYSTEMS IN THE ENERGY-POWER PLANE

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This paper presents an original sizing method for Energy Storage Systems (ESS) based on directly matching their Energy and Power (EP) capabilities with the EP demand. Starting from the system requirements and from an energy management strategy the demanded power is calculated. The objective is to size the ESS such as its power and energy capabilities are not exceeded by both power and energy demanded. Comparison between different technologies of Energy Storage Devices (ESD) is possible using this energy vs power Safe Operation Area (SOA) characterization. Special attention should be paid to comparing specific SOA across devices. Diverse energy management strategies can be synthetized in the EP plane where they can be compared and analyzed. The sizing method converges extremely fast and is a suitable to integrate it in an optimization loop. The method allows to determine directly and efficiently which technology and which sizing are the most appropriate (in terms of indicators such as mass or cost) to a certain EP demand.

ID 131

Contribution to the modelling of a Low Temperature PEM Fuel Cell in aeronautical conditions

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In recent work carried out in the LAPLACE laboratory, a model of PEM fuel cells in variable operating conditions was proposed and investigated. This model allows predicting with satisfactory results the polarization curves of PEM single cells which operate in a defined operating range. First results seem also promising if we want to extend the validity domain of this model to other operating condition ranges. The purpose of our work is to study the behaviour of this model when it is applied to a PEM fuel cell stack operating in typical aeronautical conditions in order to be able to estimate its performance. Particular attention will be paid to low pressure functioning. An experimental database is created using the Design of Experiments method and is then exploited to parametrize the model. First modelling results will be presented and analysed.

Session 5.c

Design & optimization of electric machines

ID 24

Influence of electrical machine pole number on hybrid electric vehicle global optimization.

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In this paper, the global optimization of hybrid electric vehicle (HEV) components and control is performed thanks to a specific process using genetic algorithmand dynamic programming. The pole number is considered as a variable of an electrical machine (EM) model. The influence of the EMpole number on the system optimization is analysed. Contrary to the low differences observed on the energy efficiency of the vehicle, the machine shape is highly impacted.

ID 44

Optimization of Mechanical and Magnetic Gears for Tidal Electric Generation Plant

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This article aims at comparing mechanical and magnetic gears for a typical tidal electric generation plant application. For both technologies, optimizations are performed by tuning geometric parameters to maximize the following tree objective functions: the torque per volume density, the torque per weight density and the ratio torque per material cost. Magnetic gear optimization is completed with a sensibility study and the different points to optimize for a coaxial magnetic gear. As a conclusion, it appears, in spite of a significant cost of production, magnetic gears are relevant for the tidal energy generation systems in terms of upkeep and torque density.

ID 69

Geometry Optimization to Increase Flux Control Range of a Double Excitation Synchronous Motor

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This paper deals with a structural optimization to improve the open circuit flux control capability of a double excitation synchronous motor. In this kind of motor, the air-gap flux varies according to the field current. It can be weakened or enhanced when decreasing or increasing the field current. For a specific machine geometry, minimum and maximum air-gap flux are found at certain field currents. In this paper, they are referred to as bottom and top flux, respectively. It is, therefore, desirable to minimize the bottom flux and maximum the top one to improve the controlling effectiveness of the field windings. That objective is the focus of this paper through a structural optimization. The machine is modeled by using an equivalent magnetic circuit network. Some interesting points on the non-dominated pareto front will be verified against ones obtained with the 3-D finite element method.

ID 72

Investigation of Space Harmonic Selectivity on the Behavior of Five-Phase Surface Mounted Magnets Synchronous Generator

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1: IREENA, France; 2: GE Renewable Energy

Based on the space harmonic analysis, this paper investigates the influence of opening ratio of surface mounted magnet on the behavior of a five-phase permanent magnet synchronous generator (PMSG) for renewable marine energy applications. The electromotive force (EMF) of the classical structure based on full pitch permanent magnet rotor presents many harmonics which can be projected in five dimension space. The exploitation of some harmonics contributes to the torque generation. Nevertheless some of them affect the quality of the torque and needs to develop specific control algorithm. In this paper, the proposed method is based on the choice of the appropriate width of surface mounted magnets. Thus, some undesired EMF harmonics are eliminated and the torque quality is improved. The performances of a conventional full pitch permanent magnet rotor with a reduced permanent magnet angle rotor are finally compared in regard of the reduction of the disturbance introduced by the EMF harmonics and of the torque quality.

ID 154

HIGH-SPEED PMSM DESIGN OPTIMIZATION FOR A FLYWHEEL ACCUMULATOR CONSIDERING THE CHARGE/DISCHARGE PROFILE

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Laboratoire IREENA, France

In this paper we present a design methodology of high speed permanent magnet synchronous machines considering torque and speed profiles. The optimization will minimize both the volume and the electrical energy losses. It will be shown that from a load profile it is possible to obtain by a deterministic approach the optimal geometry of the machine and the optimal control strategy with flux weakening. The methodology presented in this paper, suitable to any application, will be applied to the sizing of a flywheel energy storage system.

Session 6.a

Modelling & Analysis of power electronics

ID 5

MODEL PREDICTIVE CONTROL STRATEGY FOR DC-DC BOOST CONVERTERS

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DC-DC voltage boost converters are one of the most used power converters in research and industry. Their use increased even more with the emergence of the use of microgrids (MGs). The boost is used in the MGs to adapt the input renewable electrical power to the output load needs through an appropriate control algorithm which is linear in most cases. However, linear control provides a more sensitive system to significant perturbations. Model predictive control (MPC) of boost converters was proposed as an alternative to the linear control. However, MPC has been based mainly on the converter's linear model which still sensitive to the severe disturbances. Therefore, this work introduces a new MPC paradigm which addresses a fully nonlinear boost model in order to provide improved system performance in the case of significant disturbances. The new control consists of an MPC outer loop and an input-state linearization inner loop. The simulation results show that the new control static and dynamic performances are by far better than the existing linear control ones.

ID 62

EQUATION-FREE SYSTEM-LEVEL MODELING AND ANALYSIS OF SERIES RESONANT DC/DC CONVERTERS

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This paper introduces the equation-free method to describe the global dynamics of series resonant power converters without formulating and solving explicit equations. The equation-free approach derives an algorithm for system-level characterization by strategically simulating the component-level (micro) model. The micro model is utilized to evaluate the macro information through dynamic phasors. Then, the macro information is updated by Generalized Minimal Residual Method (GMRES). The computed solution is quite effective for analyzing the steady state and stability of the simulated power converters.

ID 77

SMALL SIGNAL MODELING AND TRANSFER FUNCTIONS FOR OPEN-LOOP BOOST PWM DC-DC CONVERTER OPERATING IN CCM UNDER CONTROL OF A PHASE-SHIFT SELF-OSCILLATING CURRENT CONTROLLER

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In this work a Boost stage operating in CCM is studied. Small-signal equivalent circuit modeling is used in order to determine the inductor current to output voltage transfer function. It is done and the way is simple and clear. Moreover the input current of the Boost stage is under control of a Phase-Shift Self-Oscillating Current Controller which is very robust and accurately tracks the current reference. Its transfer function can be approximate to unity in a bandwidth from 0Hz to 2kHz. Thus the transfer function of the current reference to the output voltage of the Boost is known. Simulations and experiments nicely verify the theoretical transfer function. Its knowledge will be useful for future works concerning a bench dedicated for a marine energy conversion chain.

ID 83

PREDICTIVE CURRENT CONTROL OF AN OPEN-END WINDING MACHINE DRIVE BASED ON INDIRECT MATRIX CONVERTER

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1: University of Bío-Bío, Chile; 2: University of Concepción, Chile; 3: Universitat Politecnica de Valencia, Spain

In this paper a predictive current control strategy for an open-end winding induction machine fed by a two-output stages Indirect Matrix Converter (IMC) is presented. Because of the topology of the IMC used, the open end winding machine is then supplied by two inverters, each one connected to corresponding machine terminal, fed from a non-insulated DC voltage source. Under this conditions, two main issues arise when using this type of DC voltage source: Common-mode voltage (CMV) and zero sequence current. The predictive current control strategy presented in this work uses only those voltage vectors which do not produce CMV at the output stages and also compensates the zero sequence voltage at the machine terminals, eliminating the occurrence of zero sequence currents in the machine windings. Results showing the performance of the proposed control scheme are presented using a PSim/Matlab simulation platform.

ID 95

EXPERIMENTAL IMPLEMENTATION OF A SINGLE PHASE MULTILEVEL BASED ACTIVE POWER FILTER USING SLIDING MODE CONTROL TECHNIQUE

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A single phase multilevel active power filter (SPMAPF) aimed to improve the power quality of distribution network is proposed. The SPMAPF is realized using a reduced switch topology of an asymmetric neutral point clamped five-level converter with self supported DC bus. To eliminate harmonics and compensate reactive power under varying load conditions a sliding mode controller is used. Moreover, an OPAL RT platform is used for real-time implementation of the proposed sliding mode control algorithm. The obtained simulation and experimental results show the effectiveness of the sliding mode control technique to compensate reactive power, and reduce the total harmonic distortion (THD) of source current below the limit specified in IEEE-519 standard.

ID 108

Multicarrier Modulation Strategy for Trinary Hybrid Multilevel Inverter

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This article presents the design of a 9-Levels Trinary Hybrid Multilevel Inverter, with a variant of the sub harmonic modulation strategy commonly used in Cascade Equal Multilevel Inverter. The proposed modulation strategy consists in a modulation function for each leg of each Full Bridge which is a piecewise linear function of the output voltage. The modulation is validated through experimental results and with a Fourier analysis of the output voltage.

Session 6.b

SS Microgrid 1

ID 7

Sizing and Rough Optimization of a Hybrid Power Generation Systems based on Renewables in a Stand-Alone Marine Context

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This paper deals with the sizing and the rough optimization of renewable energy farms in a hybrid energy production system, located in a stand-alone maritime site. The studied hybrid system will combine wind and tidal turbines, and Diesel generators. The objectives of this study is to find a compromise between the overall cost of the system for a period of 15 years and to minimize the CO2 emission. After presenting the different elements of the system (wind turbine farm, tidal turbine farm, Diesel generators, energy storage system, and the power demand), simulation constraints are defined (energy conservation) in order to form a power exchange network at the grid level. The results are analyzed for a better understanding on the effects of a hybrid energy production system over an isolated system.

ID 19

ENERGY MANAGEMENT OF STANDALONE DC MICROGRID

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Université de Technologie de Compiègne, France

The intermittent nature of photovoltaic sources ask for the complement of back-up power, such as battery and diesel generator, especially in a standalone power system. The diesel generator needs some time to start up so that a supercapacitor is proposed to compensate the deficient power during this period. After considering the loss of power converters included in the standalone DC microgrid, the proposed energy management strategy describes eight cases which take into account the slow start-up characteristics of diesel generator and the possible load shedding situation. To illustrate the performance and the behaviour of the standalone microgrid, simulation study is carried out by using real data. The obtained results verify the effectiveness of the proposed energy management strategy.

ID 20

OPERATION OF A PHOTOVOLTAIC-BASED DC MICROGRID WITH CONSIDERATION OF DYNAMIC EFFICIENCY OF CONVERTERS

Wu, Hongwei; Sechilariu, Manuela; Locment, Fabrice

Université de Technologie de Compiègne, France

Distributed renewable energy (DRE) can be easily integrated in DC microgrids via power electronic converters. Due to the highly variable nature of DRE, the working points of the converters are not fixed, so their efficiency is highly variable too. Aiming at improving the power quality and the energy efficiency, a fast estimation of instant converter efficiency based on the datasheet parameters are implemented in the control of the DC microgrid to deal with the dynamic efficiency. The results obtained by simulation based on real photovoltaic generation profile suggest that this control can improve the overall efficiency of DC microgrid and the quality of energy.

ID 21

AN IMPROVED SUPERCAPACITOR DYNAMIC MODEL BY MEANS OF SIMSCAPE

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This paper proposes a new combined model “MP_SC” which describes the dynamic behaviour of supercapacitor. The proposed model is an acausal model, developed in Simscape/Matlab. This combined model includes the electrical, thermal and ageing models and it is based on the ordinary differential equations (ODE). In order to valid the proposed model and to investigate its accuracy a test bench has been installed using a supercapacitor Maxwell technology. The comparison between simulations and experimental results reveals that the proposed model emulates with a high accuracy supercapacitor’s behaviour.

ID 56

Coordinated Home Energy Management in Community Microgrids with Energy Sharing Among Smart Homes

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This paper presents a coordination mechanism for smart homes in community microgrids (smart neighborhoods) whether photovoltaics (PV), home battery storage and electric vehicles (EV) are available. The objective of the proposed method is to reduce the electricity cost of the users, as well as the aggregated peak load of the area by establishing an energy sharing ability among neighbors. A decentralized control algorithm deployed by the smart homes is used for battery control and appliance scheduling. It is assumed that the users are the owners of these resources and that they are selfish decision-makers who focus on increasing own benefit. For the neighborhood, a dynamic price model is used, where the price is associated to the aggregated consumption of the neighborhood area. Numerical results show that proposed coordination mechanism with energy sharing provides benefits for both the users and the utility.

ID 122

OPTIMAL SCHEDULING OF A BATTERY-BASED ENERGY STORAGE SYSTEM FOR A MICROGRID WITH HIGH PENETRATION OF RENEWABLE SOURCES

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1: laas-cnrs, France; 2: Aalborg university, Denmark

A new scheduling method is proposed to manage efficiently the integration of renewable sources in microgrids (MGs) with energy storage systems (ESSs). The purpose of this work is to take into account the main stress factors influencing the ageing mechanisms of a battery energy storage system (BESS) in order to make an optimal dispatch of resources in the microgrid and enhance the storage system lifetime while minimizing the cost of electric consumption. The load demand and generation profiles are derived from the analysis of consumption and renewable production (solar photovoltaic sources and wind turbines) of the Western Denmark electric grid. Thus, the proposed microgrid is mainly fed by renewable sources and few electricity is coming from the main grid (which helps operating costs minimization). In this respect, a cost analysis is performed to find the optimal hourly power output of the BESS as well as the purchased electricity from the utility.

Session 6.c

Renewable energy

ID 27

LARGE SCALE TIDAL HYDROGEN PRODUCTION FOR FUEL CELL BASED EVS

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This paper presents the modeling and the simulation of the Hydrogen energy-based marine current power generation system. An energy storage system must cover the difference between the generation and the consumption in the isolated power system. The Hydrogen is selected based on a comparison with the other energy storage technologies that exhibits more characteristics suitable for marine applications. When the generated power is higher than the load requirements, a Proton Exchange Membrane (PEM) electrolyzer system consumes the surplus power for hydrogen generation. The generated hydrogen is stored in tanks to be used for the fueling station dedicated to fuel cell electrical vehicles. Due to the time response of the Megawatt (MW) scale PEM electrolyzer, an auxiliary energy storage system must be integrated. The LiFePO4 Battery type is selected due to its high power and energy densities compared to other battery types and a super capacitor. The battery stack is sized to feed the load during generation shortage and smoothing the fast dynamics of the power fed to the electrolyzer during power surplus

ID 73

ENERGY MANAGEMENT AND CONTROL STRATEGY FOR WATER PUMPING SYSTEM FED BY INTERMITTENT RENEWABLE SOURCES

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This paper studies an original energy management system with a control strategy dedicated to a water pumping system fed by renewable intermittent sources photovoltaic and/or wind generator without battery storage. The simulation and design are developed under a systemic approach based on power flow models. Experimental system has been set up to validate different models under various conditions. Control strategies and energy management of the pumping system fed along given intermittent powers are deduced to maximize water quantity. Finally simulations results are performed to evaluate the manager strategy.

ID 74

Computational Intelligence Applied to Power System Restoration: A Case Study of Monarch Butterfly Optimization Algorithm

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In this paper, a new computational evolutionary algorithm, namely Monarch Butterfly Optimization (MBO) was proposed for first time to enhance power system restoration (PSR) loops. The main inspiration of this algorithm was based on the migration behavior of Monarch Butterflies from the northern USA and southern Canada to Mexico. To show the effectiveness of the suggested control strategy, a two-area interconnected thermal power system was configured. Each thermal unit was equipped with automatic voltage regulator (AVR) IEEE type including single input power system stabilizer (PSS) to regulate voltage profile. On the other hand, a load frequency control (LFC) loop was proved in each control area for the frequency assessment. MBO algorithm was employed to optimize both of AVR and LFC control parameters including PID controller parameters and PSS gains. To demonstrate the superior performance of the MBO algorithm, a comparative study with other meta-heuristic algorithms was performed. Simulation results shows that the proposed MBO algorithm ensures a better dynamic responses and can improve power system restoration

ID 89

DESIGN OF A FUZZY SUPERVISION SYSTEM FOR ENERGY COST MINIMIZATION SERVICE USING VEHICLE-TO-GRID

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The increasing number of electric vehicles (EVs) connected to the grid impact negatively on the electric system. To remediate, EVs are considered as a controllable load that can participate in ancillary services. The notion of vehicle-to-grid (V2G) is adding on the flexibility that EVs can offer to the power system. In this study, a fuzzy logic supervision system was designed with the goal to minimize the cost of energy by choosing the right moment for charging or discharging the V2Gs considering the daily price of energy, the load consumption, the production of wind energy and the user's comfort. To optimize the empirically defined membership functions of the fuzzy logic controller, genetic algorithm is used. The results show that the cost of energy was indeed decreased. The same observation was done for the subscribed power for the distribution grid.

ID 140

A Symbolic Method for the Fast Simulation of Mismatched TCT Photovoltaic Arrays

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Total Cross Tied is one of the more reliable topologies that can be used in cabling a photovoltaic array. It ensures a level of electrical energy production that is higher than the one harvested by the more classical parallel connection of strings, each one made of series connected panels. The Total Cross Tied topology is superior especially when mismatched conditions, like partial shadowing, occur. Such a situation has to be suitably simulated before being implemented, both in order to predict the power production accurately and for designing the proper power processing stage and switching converters for the maximum power point tracking function. A fast and accurate simulation is also useful for model-based diagnostic purposes. This paper shows an effective method for the simulation of Total Cross Tied photovoltaic arrays: it can be implemented in any simulation platform and it has high potentialities also to be ported on embedded systems for real time simulation.

Session 7.a

SS Thermal Management of power electronics and electrical machines

ID 8

Dimensional analysis and surrogate models for the thermal modelling of electronic components

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This paper presents the use of a surrogate modelling technique, called VPLM (Variable Power Law Meta-model) to conduct the thermal modelling of power converter electronic components. The proposed methodology combines dimensional analysis and surrogate modelling technique to build analytical models from finite element simulations. The thermal models of a film capacitor and a heatsink are built. Finally typical utilizations of the thermal models are presented.

ID 50

GLOBAL ELECTRO-THERMAL MODELLING AND CIRCUIT-TYPE SIMULATION OF SIC MOSFET POWER DEVICES IN SHORT-CIRCUIT OPERATION FOR CRITICAL SYSTEM ANALYSIS

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The purpose of this paper is to present, for the first time, a global transient electrothermal modelling and simulation results of commercially recent silicon carbide (SiC) power MOSFET devices. The developed models aim is faithfully transposing specifically experimental short-circuit (SC) behaviour of the studied components, ready-to-use for the analysis of an inverter-leg malfunctioning. After extensive experimentation, a thermal model of the SiC die allows to develop models of gate-leakage current and drain-source current during SC. After having verify the robustness of the proposed models an original circuit-type with an easy implementation is performed through a commercial circuit simulation tool.

ID 93

3D ANALYTICAL MODELLING OF HEAT SINK HEAT DISTRIBUTION FOR FAST OPTIMISATION OF POWER CONVERTERS

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With the development of embedded systems, it is crucial to reduce weight of equipments. In power converter, heat sink is a heavy part that often can be reduced in volume and weight. There are several models and methods to calculate the heat sink thermal resistance, however the more precise these methods are, the more time consuming they are and thus they can be hardly integrated in an optimization routine. Analytical models are a good compromise between execution time and precision of results. They are usually one-dimensional models which are simple but do not take into account heat spreading effects, which is important when power electronics sources are small compared to their heat sink. This paper develop three-dimensional analytical model of plate fins heat sink in forced convection, which will be numerically validate and which will be used in an optimization routine to reduce the weight of an existing heat sink.

ID 96

Lumped parameter thermal model of permanent magnet synchronous machines

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This paper describes a thermal equivalent circuit of Permanent Magnet Synchronous Machines (PMSM). Conductive heat transfer in all directions is taken into account. Specific care has been taken to represent them by equivalent circuit. The conductive heat transfer in heterogeneous media like slots and the convective heat transfer in the airgap and the end-winding are studied.

ID 144

Thermal Analysis of a Double Excitation Synchronous Machine

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In this paper, a thermal analysis of a synchronous machine using the double excitation principle is presented. Two global field windings introduce not only a more complicated structure but also additional heat sources and heat evacuation difficulties. In this research, the thermal analysis is accomplished by using a lumped parameter model, and results are compared with experiments.

Session 7.b

SS Microgrid 2

ID 124

DIESEL-WIND-PV POWER GENERATION FOR A WEAKLY MESHED MICRO-GRID APPLICATIONS

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This paper deals with the establishment of a multi-source system dedicated to isolated areas such as sub-Saharan African countries. The electric power production system includes: a 13 kVA diesel generator, a 6kW photovoltaic generator, a 1.1kW wind turbine and a pack of lithium-ion battery. This system is connected to an electrical micro grid through a power-controlled 3-level NPC inverter. The diesel generator is used as the main energy source which ensures the DC-bus voltage through a 3-level NPC rectifier controlled by the vector Pulse Width Modulation (PWM) strategy. The wind turbine and the photovoltaic generator are used to increase the penetration ratio for renewable energies to the system. In fact, a part of the renewable is produced by the wind turbine through a 3-level NPC rectifier controlled by the maximum power point tracking (MPPT), and the other part is produced by the PV-generator through the midpoint-boost converter controlled also by MPPT method. Finally, the battery pack is proposed to compensate the produced intermittent energy. Some simulations are done using Matlab/Simpower software and they will be improved for final paper by adding the contribution of the battery to illustrate the scenario.

ID 136

PREDICTIVE DIRECT POWER CONTROL BASED ON DISTURBANCE REJECTION PRINCIPLE FOR THREE-PHASE SHUNT ACTIVE POWER FILTER UNDER DIFFERENT VOLTAGE CONDITIONS

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Predictive direct power control (P-DPC) has been suggested as an effective alternative to the conventional direct power control (DPC) applied to PWM converter such as rectifier and active power filter (APF). It is characterized by a high transient dynamic, which makes it an interesting alternative for classic direct power control. Moreover, in the presence of a non-linear load, the grid currents would become highly distorted under unbalanced and perturbed voltage grid conditions. In order to resolve the problems mentioned above, the present paper suggests an improved P-DPC for APF based on disturbance rejection principle, which is able to operate under balanced, unbalanced and distorted grid voltages conditions and can obtain sinusoidal grid currents with a good total harmonic distortion (THD). Simulation results and comparative study are presented to confirm the efficiency of the proposed approaches.

ID 139

WIND-PV-BATTERY SYSTEM BASED OF PEAK LOAD COMPENSATING FOR WEAK GRID-SUPPORTING

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People in developing countries have very limited access to energy, especially in rural areas. But, in the bigger cities, national electricity companies with weak power grids are overloaded. This induces interruptions of electricity supply which can take several hours to several days. In this context, consumers use diesel generators that are very noisy and highly polluting. Also, in this paper, an alternative way is proposed which consists in replacing the diesel by distributed generation systems, that must be located at different nodes of the weak grid. This can help to provide supply continuity to consumers under certain conditions. Consequently, any interruption of the energy supply would induce a penalty to the grid manager. This paper presents the methodological approach of analysis of the weaknesses of the network and it proposes a multi-objective sizing approach, based on the PSO method. Its particularity is the using of the cost function of the penalties according to the duration of the interruptions. The analysis is based on the actual data of the network. It highlights the characteristics of the grid, defining the choice of the sizing method. Simulations results are presented and analyzed.

ID 153

Decentralized H_{infty}-based control strategy for DC-grids

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This paper presents an $\mathcal H_{\infty}$ control design for a DC-grid, considering limited information of the rest of the grid. Proposed strategy is compared with previously reported plug-and-play and droop controllers. The paper shows both PSCAD/EMTDC simulation and experimental results in a scaled prototype.

ID 160

DEVELOPMENT OF A PHOTOVOLTAIC LOW VOLTAGE DC MICROGRID FOR BUILDINGS WITH ENERGY STORAGE SYSTEMS

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laas-cnrs, France

In order to develop a sustainable datacenter, which would help to validate energy management and task scheduling algorithms, a low voltage direct current (LVDC) microgrid (MG) has been deployed in the ADREAM Building-Integrated Photovoltaic (BIPV) of the LAAS-CNRS in Toulouse, France. This MG is composed of a 1 kWp PV source, 300 Ah – 36 V lead-acid batteries, 330 F – 48 V supercapacitor (SC) pack and DC loads (cloud servers, USB chargers, sensors monitoring an apartment…). A very simple and efficient energy flow management strategy, based on the "DC bus signaling" approach has been implemented. It takes advantage of the DC bus architecture and enables a scalable electrical structure constituted of several sources, loads and storage elements easy to connect/disconnect via their converters. The development of this MG put in evidence the need for future theoretical developments regarding the determination of optimal DC bus signaling thresholds.

Session 7.c

Modeling & simulation of electric machines & electromagnetic devices 1

ID 17

State-space-nodal rotating machine models with improved numerical stability

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This paper presents a set of rotating machine models, namely synchronous, asynchronous and permanent magnet synchronous machines, with increased stability characteristics compared to traditional state-space based methods. In this work, the machine models are all derived using the state-space-nodal (SSN) theory. This results in machine models that are stable without any parasitic load or numerical snubber. This is an important improvement for these models in solver packages based on the state-space approach, such as SimPowerSystems or PLECS.

ID 42

COMPARISON BETWEEN OPTIMIZED TOPOLOGIES OF PERMANENT MAGNET THRUST BEARINGS AXIALLY STACKED WITH BACK-IRON

Van Beneden, Maxence; Kluyskens, Virginie; Dehez, Bruno

Université catholique de Louvain, Belgium

This paper deals with the optimization and the comparison of passive magnetic thrust bearings made up of axial stacks of permanent magnet rings. Various topologies are considered, depending on the polarization direction of the permanent magnet rings and the presence of back-iron. The coulombian approach and the method of image charges are used to determine the load capacity of topologies with back-iron. On this basis each topology is optimized in order to minimize the permanent magnet volume for a fixed load capacity, airgap thickness and remanent flux density. Varying these parameters, scaling laws of the optimum permanent magnet ring dimensions are derived to allow fast sizing and comparison of the topologies. The latter highlights that the topology with Halbach configuration and back-iron is the most performant, but that the topology with axial polarization is almost as good.

ID 61

ANALYSIS OF CORE LOSSES DISTRIBUTION IN A SWITCHED RELUCTANCE MOTOR

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1: ISEP; 2: FEUP; 3: INESC-TEC

Hybrid (HEV) and electric vehicles (EV) have been known a growing interest in the last years. Switched reluctance machines (SRM) are an option for these vehicles. In high speed range, core losses can be very significant, but for SRM its estimation is very complex. The main reasons are the non-sinusoidal flux waveforms and nonlinear operation features. Empirical formulas are often considered for core losses estimation in conventional electrical machines, but this is insufficient for SRM. This paper presents a preliminary study on core losses distribution in SRM. The main goal is to identify the core sections with higher losses.

ID 85

Numerical Study of an Electromagnetic Valveless Peristaltic Micropump

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Microfluidic devices are aimed to manipulate micro volume of fluid. These devices find applications in various domains such as medical care, diagnosis or electronic. A key element in those system is the micropump. Many designs have been proposed. In this paper a planar peristaltic micropump is studied. Fluid is transported between two thin plates. Those plates are bended by Lorentz forces which ensure the propagation but also the sealing. In order to evaluate its performances a model based on thin laminated plate theory, magnetostatic and mechanical contact is developed. The equations are then solved using analytical and finite element methods. The model is compared to 3D simulation performed with COMSOL Multiphysics and can be used to estimate displacement, volume of the bubble, flow rate and stresses or to study control scheme.

ID 134

DESIGN OF A NOVEL CONCEPT OF SYNCHRONOUS MOTOR FOR TORQUE RIPPLE IMPROVEMENT

ASFIRANE, Salim; Hlioui, Sami; Ben Ahmed, Hamid; Vido, Lionel; Gabsi, Mohamed

SATIE, France

In this paper, a novel design of synchronous machine is presented, the Multi-Stack Flux Modulating Machine (MSFModM). The MSFModM is made of 2 separate machines combined together into one multi-stack structure. The 2 combined stators share the same concentrated armature winding. A 2-D electromagnetic Finite Element Model (FEM) is built for a 3-phase 6/4 motor (6 stator teeth, 4 rotor teeth) and a Magnetic Equivalent Circuit (MEC) is used to evaluate the 3-D effect of the multi-stack machine and to correct the 2-D FEM flux linkage evaluation. The MSFModM concept is compared to a Biased Flux Permanent Magnet Motor (BFPMM). The two motors are supplied by three-phase sine wave currents and comparisons are carried out in terms of flux linkage, back-EMF and torque as the MSFModM exhibits a lower torque ripple.

Session 8.a

Islanded & DC microgrids

ID 15

A TWO-STAGE STOCHASTIC OPTIMIZATION FOR SCHEDULING THE OPERATION OF ELECTRICAL BATTERIES

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RWTH Aachen, Germany, Institute for Automation of Complex Power Systems

In this work, we investigate a two-stage stochastic optimization problem for scheduling the day-ahead (DA) operation of charging and discharging electrical batteries under uncertainties. Relevant uncertainties considered are in the electrical generation trough photovoltaic (PV) units, in the electrical demand and the imbalances prices. The problem is executed by an aggregation service provider acting as energy retailer connected to a fleet of customers, e.g. larger industry facilities which are equipped with photovoltaic units and electrical storage, i.e. batteries. The aim of the aggregator is to minimize its total electricity costs including costs for additional imbalance energy when being faced by uncertainty.

ID 47

Voltage Harmonic Distortion Compensation with non-Linear Load Sharing of Droop Controlled Islanded Microgrids

Moussa, Hassan (1); Martin, Jean-Philippe (1); Pierfederici, Serge (1); Moubayed, Nazih (2)

1: Université de Lorraine, France; 2: Lebanese University, Lebanon

Harmonics are found to have deleterious effects on power system equipment including transformers, capacitor banks, rotating machines etc. This paper describes the voltage distortion generated by nonlinear loads and proposes a new Harmonic Droop Control to reduce the voltage harmonic distortion at the point of common coupling (PCC) and to share the harmonic power between parallel islanded Inverters controlled by classical frequency droop method. Simulation and experimental results are presented to show the competence of the proposed algorithm in achieving harmonic power sharing and in improving the voltage harmonic distortion at the PCC.

ID 81

FREQUENCY ADAPTATION FOR A THREE-PHASE GRID-FORMING INVERTER FOR STAND-ALONE SYSTEMS

Ghanty, Yann; Roux, Nicolas; Roboam, Xavier

LAPLACE, University of Toulouse, CNRS, INPT, UPS, Toulouse, France

In the classical “super grid”, frequency is used to communicate between the different units in order to ensure the power balance. When there is a power unbalance, the rotating units directly connected to the grid (without electronics device) naturally change the grid frequency, so all the other sources capable of primary frequency regulation can participate to the power balance. For classical stand-alone micro-grids, diesel generators are classically used to form the grid and ensure the power balance. However, in micro-grids without rotating units directly connected to the grid, a battery inverter is required to form the grid. Classical grid-forming inverter creates a constant frequency given by a clock, regardless of the power balance. If there is an unbalance, the battery has to ensure alone the power supply, unless there are communication cables between the different sources. This paper proposes a control strategy for a three-phase grid-forming inverter in order to change the frequency during a power unbalance and thus recreate a means of communication between the different sources. The frequency behaviour during a power unbalance of this system is simulated and compared to the frequency behaviour of a classical grid-forming diesel generator.

ID 107

HEURISTIC VS LINEAR PROGRAMMING FOR OPTIMIZATION OF MICRO SMART GRID ENERGY MANAGEMENT

BOURBON, Rémi (1); NGUEVEU, Sandra (2); ROBOAM, Xavier (1); SARENI, Bruno (1)

1: LAPLACE, France; 2: LAAs, France

The paper aims at optimizing a smart grid energy management. The power chain includes renewable sources (wind turbines) and Lithium Ion storage device. The modeling approach is based on power flow models used to run linear optimization based on linear models. This class of global optimization methods allows planning the management with “a priori” knowledge of future events in the environment. The application of this case study is related to islanded electric grids. For the optimization, the economic aspect is put forward especially by optimizing the cost reduction. Optimization are made on one full year. Results obtained with linear programming (LP) will be tested on a non-linear model and compared with a second management method based on a rule based heuristic without “a priori” on future events. The comparison will allow to evaluate this heuristic method and to help future developments of such management methods applicable at real time.

ID 120

A SURVEY ON OPTIMIZATION APPLIED TO MULTI-SOURCE SYSTEMS: FROM MICRO-GRID APPLICATIONS TO ELECTRICAL SYSTEMS

ABBES, Dhaker (1); FRANCOIS, Bruno (2); ROBYNS, Benoit (1)

1: L2EP, HEI Yncrea Haut-DE-France, France; 2: L2EP , École centrale de Lille, France

This paper is a survey focusing on the optimal design and/or supervision of multisource systems. A detailed state of the art and many case studies are proposed such as : design and supervision of a hybrid wind-photovoltaic system with batteries, a hybrid railway power station and day-ahead optimal operational planning of generators in an urban electrical network. It is the fruit of several years of investigations that leads to many innovative solutions and results concerning methodologies for explicit and implicit optimization of multi-source systems.

ID 123

Active and Reactive Power Distribution Among Multiple DFIG WTSs in an Isolated Microgrid

Litvani, Lilla; Stumpf, Peter; Hamar, Janos

Budapest University of Technology and Economics, Hungary

Wind energy sector is a well-researched field since depletion of fossil sources and environmental pollution issues led to the popularization of renewables. Many efforts have been made to optimise its power production and to minimize its losses. In case of m different sized power plants, due to different MPPs, if the demand is below the sum of their maximum power production at the given wind speed, it is highly likely that the optimal distribution will not be exact. There are several possibilities, one of them is to share the demand equally among them etc. The distribution of active and reactive powers will have an effect on each other and thus the optimal solution.

Session 8.b

Modeling & simulation of electric machines & electromagnetic devices 2

ID 4

Influence of dynamic magnetic eccentricity on sleeve bearing housing vibrations of induction motors considering electromagnetic field damping

Werner, Ulrich

Georg Simon Ohm University of Applied Sciences Nuremberg, Germany

The paper shows the influence of dynamic magnetic eccentricity on the sleeve bearing housing vibrations of induction motors, considering electromagnetic field damping. The analytical model contains electromagnetic forces in respect of electromagnetic field damping, stiffness and internal (rotating) damping of the rotor, dynamic magnetic eccentricity, stiffness and damping of the support, and stiffness and damping of the oil film of the sleeve bearings. Based on an analytical rotordynamic model, a practicable method is presented, showing how to consider electromagnetic field damping, when analyzing forced vibrations caused by dynamic magnetic eccentricity, which can also be adopted in a Finite-Element-Analysis

ID 112

SLOTS & POLES COMBINATION INFLUENCE ON THE VIBRO-ACOUSTIC BEHAVIOR OF AXIAL TYPE FLUX SWITCHING PERMANENT MAGNET MACHINES

BENHAMIDA, Mohammed ali; Ennassiri, Hamza; Dhifli, Mouheb; Barakat, Georges

Laboratoire GREAH, France

The aim of this paper is to investigate the vibro-acoustic behavior due to electromagnetic origins of axial type machines. This investigation is based on the analysis of slots/poles combinations influence on the machine’s electromagnetic performances. Also, the impact on the emitted vibrations/noise is explored. To achieve this goal a comparative study between 12 slots and 10, 11, 13 and 14 rotor poles configurations of an axial type FSPM machines is carried out. The comparison includes the magnetic field components, axial and radial forces applied on the stator core, structure natural frequencies and their corresponding deformations (modes), sound pressure in time and frequency domains. The developed multi-physic model for this investigation is based on a quasi 3D Finite Element (FE) electromagnetic model coupled to a 3D FE vibro-acoustic one. The electromagnetic and vibro-acoustic models are respectively built using Flux and Ansys mechanical commercial software.

ID 113

VIBRO-ACOUSTIC RESPONSE OF A DISCO¨IDAL SWITCHING FLUX PERMANENT MAGNET MACHINE DUE TO ELECTROMAGNETIC ORIGIN

Ennassiri, hamza; Benhamida, Mohammed ali; Dhifli, Mouheb; Barakat, Georges

Laboratoire GREAH, France

The aim of this paper is to present two modelling approaches for the investigation of the vibro-acoustic behavior due to electromagnetic origins in electrical machines. The first modelling approach is based on a full transient vibro-acoustic analysis, while the second one is based on modal superposition analysis. The two modelling approaches have been used for the investigation of the vibro-acoustic response of a three-phase disco¨ıdal switching flux permanentmagnet (DSFPM) machine. This multi-physic study relies on a weak coupling between two 3D Finite-Element (FE) models: A magnetic model employed for the computation of the machine's electromagnetic performances and a vibro-acoustic model used in order to quantify the vibrations and emitted acoustic noise. Results comparison between the two modelling approaches shows the effectiveness of the modal superposition model in terms of precision and computation time.

ID 135

Radial and tangential pressures on the traction induction motor for railway application: skew impact

Despret, Ghislain

Ecole Centrale Lille, France

Acoustics comfort is an increasingly important factor at the design stage of electrical machines associated to converters. The objective of this paper is to show the impact of the skew about the Maxwell pressures: radial and tangential components. Pressure harmonics versus space and frequency on induction motor are evaluated with no-skew and skew rotor with 3D finite element approach. The results are compared with analytical formulation in order to establish a fast and accurate analytical model to be used in an optimization tool. Experimental measurements with two induction motors with skew rotor and no-skew rotor validate our results.

ID 138

ESTIMATION OF DAMPER BARS LOSSES IN LARGE SYNCHRONOUS ALTERNATOR USING BAR CURRENT WAVEFORMS

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1: Laval university, Canada; 2: L2EP, ENSAM, Lille, France

Copper losses in the damping cage of a large hydraulic alternator are always difficult to quantify and discriminate to other pole shoe losses. The bar currents have a high harmonic content and the current density distribution is non uniform. This makes the measurement and computation of damper bar losses more difficult. In this paper, an analytical model in the frequency domain is used to estimate these losses using bar current waveforms. The model performances are confirmed by several magnetodynamic finite elements simulations. Influences of proximity effects and magnetic saturation on the model performance are also studied. This model allows a quick assessment of the bar copper losses. It is applied to analyze measured damper bar currents and estimate losses in different steady-state operation modes of a hydro generator.

ID 145

MODELING AND CHARACTERIZATIONS OF ACOUSTIC RESONANCE IN METAL HALIDE LAMPS

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LAPLACE, Université de Toulouse, CNRS, INPT, UPS, France

This paper presents a modeling of lamp voltage with acoustic resonance (AR) occurrence in metal halide (MH) lamps. The modeling is implemented in PSIM and is based on amplitude modulation (AM). Then, a lookup table of the lamp voltage is proposed. Both periodic or stochastic signals can appear on voltage envelope when AR occurs in MH lamps. Thus, a very simple circuit for AR detection of voltage envelope is also given. Simulation and experimental results of AR detection show that the designed circuit can detect AR well. In addition, characterizations of voltage envelope are analyzed by fast Fourier transform (FFT).

Session 8.c

Transportation & embedded network applications

ID 30

Simultaneous optimization of sizing and energetic management - Application to hybrid train

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The increasing number of railway traffic and the environmental issue demand to find new solutions to provide energy to autonomous train with diesel power supply on board. Using hybrid diesel train is an interesting technology solution but this kind of multisource system presents new scientist and methodology challenges. Thus, the problematic is focus on the design and the energy management of the different sources for this system. Moreover, these two fields are linked to each other. Indeed, there is a strong influence of the sizing on the energetic management but the reverse is also true. This paper deals with a new optimization method to perform the design of both the hybrid sources sizing and the energetic management system. The multi-sources system is modelled by a power flow model and the energetic management is based on the filtering method. This direct optimization problem is solved by the Sequential Quadratic Programming (SQP) algorithm. Thus, in this paper, this optimization method is applied to a real railway study case and the results are presented.

ID 33

Management and sizing of a combined serial-parallel hybrid architecture for river ship application

Derollepot, Romain; Vinot, Emmanuel

IFSTTAR, France

Commercial river ships present a good alternative to road transportation in terms of carbon dioxide emissions but not obviously concerning other pollutants. A solution to reduce fuel consumption and respect future pollutant norms can be to use a combined serial-parallel hybrid architecture. Engines dedicated to road transportation with their depollution systems can be used if high downsizing is performed. This paper investigates the potential of fuel economy of this hybrid architecture focusing on the management of the system.

ID 55

PARTIALS DISCHARGES (PD) SUSCEPTIBILITY AND PREDICTING TOOL OF HIGH VOLTAGE COMPONENTS IN AIRCRAFT SYSTEM.

KOLIATENE, Flavien (1); LAURENS, Sophie (2); GENOULAZ, Jérôme (1)

1: Safran Electrical & Power, France; 2: CERFACS, France

This paper present the method for the numerical resolution allowing the prediction of PD for the high voltage electric components in new aircraft generation. The advent of more electric aircraft induces the increase of voltage level for reducing the mass of electrical system. This concept generates an increasing stress on the Electrical Insulation System (EIS) and causes the susceptibility in Partial Discharge (PD) phenomena of the high voltage electrical equipments. The risk of PD ignition around Electrical Wiring Installation Systems (EWIS) component could lead to a degradation of EIS, affect the reliability and inducing lifetime reduction of the system. Taking into account PD or corona phenomenon, the power electric (High voltage) equipments must undergo qualification test ([BMS 13-78C],[prEN2267-011],[prEN2591-227]) to control their behavior to PD perspectives. In order to prevent the susceptibility of HV devices, the development of a prediction tool makes it possible to specify the EIS sizing to design robust equipment and avoid PD ignition. The hypothesis and the resolution of mathematicals équations provided with the post-processing the PD ignition and localization by doing a comparative study with Paschen's law. This tool takes account the impact of the parameters such pressure and temperature on the PD ignition and the cable example are highlighted, as well as, their comparison with the simulation results. In order to develop reliable systems, Safran Electrical & Power (SEP) has to master the physics of PD, the mapping of electric field around the systems, to put in place new rules for the design of Electric Insulation System (EIS), to prevent PD ignition during the design and the qualification of equipments.

ID 76

Optimization of meshed electrical networks by increasing algebraic connectivity

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This article proposes an innovative method for optimizing the connectivity of meshed electrical networks used for current return in aircrafts. The networks are modelled as graphs; spectral graph analysis is used to study their complexity. Thanks to the insight into graph's spectrum, we propose a multi-scale reading of meshed networks. Finally, we develop an optimization algorithm which increases the second eigenvalue of the graph's spectrum. The main objective is to decrease the DC resistance of the network while keeping low its total weight. The optimization algorithm is applied to a representative model of a real aircraft current return network. The research is concluded with the result analysis by checking the DC voltage drops in steady state conditions.

ID 90

Simulation of the Energy storage system of a Full-Electric Ferry : From the PWM to the Aging

Hmam, Sadok (1); Olivier, Jean-Christophe (2); Bourguet, Salvy (2); Loron, Luc (2)

1: SERMA Ingénierie, France; 2: IREENA, University of Nantes, France

This paper address the simulation of complex systems which consider phenomena with different time scales. Such problems are encountered on electrical systems studies which tried to take into account the power converter and its control laws, over representative operating cycles of several hours. Moreover, when storage elements are integrated into the power chain, there aging may need to consider larger time scales, which can then exceed a few years. It is the reason why most studies separate the time scales between the slow dynamics for the energetic, thermal and aging phenomena, and the fast ones to study the power converter, and its control laws. This paper presents an original cycle-based and multi-rate method for the simulation of power systems with a wide range of time scales and with high mutual dependency between the fast and slow state variables. This method is applied to the supercapacitor energy storage system of a full-electric ferry. The proposed simulation results take into account in the same time the switching of the power converter and the aging of the supercapacitor, with a reduction of the computational effort greater than 10E5. In other words, while a full calculation of the problem takes 10 centuries on a personal computer, the proposed method permits to have the same result in only 15 days.

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ABDELHEDI	Riadh	*132*	*Session 4.a*
ABDOU TANKARI	Mahamadou	*139*	*Session 7.b*
AGBLI	Kréhi Serge	*27*	*Session 6.c*
Ait-Ahmed	Mourad	*77*	*Session 6.a*
AKACHA HELAL	Ibtissem	*99*	*Session 1.c*
Al-Haddad	Kamal	*22, 95*	*Session 2.a, Session 6.a*
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Alkorta	Patxi	*64*	*Session 2.b*
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AMMARI	Ahmed Chiheb	*132*	*Session 4.a*
Anvari-Moghaddam	Amjad	*122*	*Session 6.b*
Araújo	Rui Esteves	*61*	*Session 7.c*
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Barakat	Georges	*112, 113*	*Session 8.b, Session 8.b*
BARAKAT	Mahmoud	*27*	*Session 6.c*
Barambones	Oscar	*16, 64*	*Session 2.b*
Baraston	Arnaud	*82*	*Session 3.a*
BARASTON	Arnaud	*129*	*Session 3.a*
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Ben fadhel	Yosra	*91, 95*	*Session 6.a*
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Benkhoris	Mohamed-Fouad	*72, 77*	*Session 5.c, Session 6.a*

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SLAMA-BELKHODJA	Ilhem	*133*	*Session 2.a*
Soualhi	Abdennour	*161*	*Session 1.c*
Spagnuolo	Giovanni	*75, 140*	*Session 1 a, Session 6.c*
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Stojanović	Vojislav	*76*	*Session 8.c*
Stumpf	Peter	*123*	*Session 8.a*
TAGHIA	Bouazza	*115*	*Session 5.a*
TAHRI	AHMED	*28*	*Session 2.c*
Tani	Angelo	*163*	*Session 1.c*
Tientcheu	Mathias	*106*	*Session 3.c*
Tognan	Malik	*102*	*Session 4.b*
Tormo	Daniel	*152*	*Session 3.b*
Touhami	Sarah	*96*	*Session 7.a*
Trigui	Rochdi	*116*	*Session 4.a*
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Trovão	João Pedro	*98*	*Session 4.a*
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Van Beneden	Maxence	*42*	*Session 7.c*
Varais	Andy	*119*	*Session 2.c*
VENET	Pascal	*132*	*Session 4.a*
Ventoruzzo	Geraldine	*111*	*Session 1 a*
Verdu	Olivier	*102*	*Session 4.b*
Vermeersch	Pierre	*43*	*Session 1.b*
Viarouge	Philippe	*138*	*Session 8.b*
VIDO	Lionel	*10, 69, 144*	*Session 2.c, Session 5.c, Session 7.a*
Vido	Lionel	*134*	*Session 7.c*
Vinot	Emmanuel	*24, 33*	*Session 5.c, Session 8.c*
Vivert	Miguel	*108*	*Session 6.a*
Vivier	Stéphane	*84*	*Session 3.c*
Vuong	Tan-Hoa	*99*	*Session 1.c*
Walter	Lhomme	*109*	*Session 3.b*
Walz	Stefan	*141*	*Session 2.b*
Wang	Gang	*62*	*Session 6.a*
Welles	Joris	*101*	*Session 3.b*
Werner	Ulrich	*4*	*Session 8.b*
Wiesner Hernandez	Arnold	*146*	*Session 5.a*
WU	Hailong	*13*	*Session 3.c*
Wu	Hongwei	*19, 20*	*Session 6.b, Session 6.b*
Yang	Nanfang	*18*	*Session 3.b*
Yin	Changjie	*19*	*Session 6.b*