EES-UETP

Electric Energy Systems University Enterprise Training Partnership

Course on:

Advanced Methods and Models for Power System Dynamic Simulation

20-22 June 2012

Organiser: Institute of Energy Systems, Energy Efficiency and Energy Economics of TU Dortmund

Course Leader: Prof. Dr.-Ing. Ch. Rehtanz

Local organiser: Department of Electrical Power Systems of University Duisburg-Essen, Germany

1. Course outline

In light of perceived changes in electrical power systems in near future where the distributed and bulk renewable generation will significantly increase, electricity markets will become much more liberated and customer participation will start to play important role in operation and control of power systems the need for efficient and accurate simulation tools and models for a very large interconnected power systems becomes paramount. The emphasis in future power system operation and control, due to the reasons stated above will be on close to real time control which necessitates accurate dynamic models of the power system. This course will discuss some of the most recent developments in the area of very large (continental size) power system modeling and dynamic simulation applying very advanced computational methods.

The new models and algorithms developed over the last few years, and in particular as a part of collaborative EU FP7 PEGASE research project (http://fp7-pegase.eu/), will be presented and illustrated using various industrial prototypes issued by PEGASE consortium.

2. Scope and objectives

The course is designed to give industrial practitioners, researchers, academics and postgraduate students a solid understanding of new models and advanced algorithms to be used in dynamic simulations of very large power systems.

Course objectives:

- To present new models of innovative equipments based on power electronics (Wind turbines, HVDC…) suitable for the transient simulation of very large power system.
- To present technique allowing to exchange models without ambiguity.
- To introduce advanced algorithms allowing to achieve very fast simulations by exploiting the new parallel architectures.

- To highlight the impacts of the modelling on the performance/accuracy of the solver.
- To present methods dedicated Dynamic Security Assessment for very large systems where a trade-off between accuracy and efficiency must be made.

3. Who should attend

This course is intended for all technical staff, engineers and software developers from electrical power utilities, industry, manufacturing and consulting companies as well as educational and research institutions who deal with the simulation of large power systems.

4. Course duration

Three-day course, from Wednesday 20th to Friday 22nd of June 2012 March 2011.

5. Course venue

University of Duisburg-Essen,
Engineering Faculty
El. Power Systems Department
BA Building, room BA 050
Bismarckstrasse 81
D-47057 Duisburg (Germany)

6. Course program

Day 1 Wednesday 20th of June, 2012

10:00 -10:30 **Registration**

10:30 -11:00 **Welcome and Introduction. Course overview.** *(I. Erlich)*

11:00 -12:00 **Short review of power system dynamics.** *(T. van Cutsem)*
The basic concepts of power system dynamics and stability will be shortly reviewed and illustrated through simple examples. Classification into angle, frequency and voltage instabilities, short vs. long-term.

12:00- 13:00 **Modelling of innovative equipments based on power electronics.** *(I. Erlich)*
This lecture will focus on the simplified modeling of wind farms, VSC, HVDC and FACTS devices for power system dynamic studies. In line with the current trend the emphasis will be on the derivation and parameterisation of generic models, which:
- are simplified, but detailed enough to represent the behaviour of the components relevant to power system stability
- are capable of simulating wind turbines of different manufacturers and different wind turbine concepts
- allow modelling of whole wind farms consisting of any realistic number of wind turbines.

The lecture will deal extensively with one particular optimization technique for parameter identification, namely Mean Variance Mapping Optimization (MVMO). In this approach the parameter identification is formulated as an optimization problem, and a heuristic optimization method called MVMO is used for the solution. Using illustrative examples, it will be demonstrated that a fairly accurate representation of the dynamic behavior of whole wind farms can be achieved by using simplified models.

13:00 -14:00 **Lunch**

14:00 -15:00 **Modelling of innovative equipments based on power electronics.** *(I. Erlich)* cont'd

15:00 -16:00 **Modern methods to solve large scale problems.** *(P. Laurent)*
This lecture deals with modern numerical methods for integrating the non-linear differential algebraic system modelling a very large scale power system simulation. A special focus will be made on implicit method and the link between the main operations: time step choice, inner Newton loop, linear solver, LU factorization etcetera.

The efficiency of time integration using sequential and parallel sparse direct solvers will be analysed. The aim is to assess flexible numerical strategies and solvers taking into account some power systems specificities. The study is illustrated using large realistic test cases.

16:00 -16:15 **Coffee break**

16:15 -17:15 **Modern methods to solve large scale problems.** *(P. Laurent)*
cont'd

17:15 -18:30 **Full accuracy simulator demonstration.** *(B. Haut)*
A demonstration of the EUROSTAG power system simulator will be performed. Various concepts previously introduced such as the block diagram model edition or the impact of required accuracy on the step size will be illustrated.

Day 2 Thursday 21st of June, 2012

10:00 -12:00 **Modelling of innovative equipments based on power electronics.** *(I. Erlich)* cont'd from day 1

12:00- 13:00 **Modelica or how to exchange models without ambiguity.**
(P. Panciatici)
While considerable progress has been made in recent years on the development of common formats for the exchange of power system data, there is no common format for the exchange of mathematical models. The development of such a common format would ensure that all TSOs have a common understanding of how a particular device or control system operates. Thanks to this common understanding, TSOs would be able to simulate accurately, using their own tools, the effect that their neighbours' system could have on the security of their own system. The SCILAB/Xcos mathematical platform for modelling, optimization, and simulation therefore is used to demonstrate the capability of dealing with an open modelling approach. Because the modelling equations are visible, this platform provides the capability to build reference models in an open framework and to compare these reference results with those obtained from commonly used commercial simulation packages. Examples of modelling and simulation using this computational platform will be given.

13:00 -14:00 **Lunch**

14:00 -15:00 **Advanced parallelization methods.** *(F. Magoulès)*
Domain Decomposition methods are well suited for parallel computations. This course presents a selection of some Domain Decomposition methods. The main topics considered include

Domain Decomposition methods (in space and in time) and parallel and distributed algorithms based on Domain Decomposition methods.

15:00 -15:30 **Coffee break.**

15:30 -17:30 **DTS demonstration.** *(B. Haut)*
A demonstration of a DTS including advanced parallelization techniques will be performed. The impact of operator decisions on the system will be highlighted.

19:30 **Course dinner**

Day 3 Friday 22nd of June, 2012

10:00 -11:30 **Modelling of innovative equipments based on power electronics.** *(I. Erlich)* cont'd from day 2

11:30- 12:30 **Importance of correct modeling.** *(B. Haut)*
This course will illustrate some common problems which could occur with user-defined models using block diagram. Typical examples are the impossibility to handle "discontinuous" state variables using the classical accuracy/step size control or the possibility to define a model having no mathematical solution.

12:30 -13:30 **Lunch**

13:30 -15:30 **From detailed to simplified simulation.** *(T. van Cutsem)*
The lecture will focus on long-term simulation methods suited to Dynamic Security Assessment, when some degree of approximation can be accepted. Two types of accuracy relaxation will be considered: in time and in space. The former consists of using large time steps to filter out the less significant dynamics. The latter is based on a particular domain decomposition which allows exploiting the localized effects of a majority of disturbances. Examples from a real-life system will be provided.

15:30 -16:30 **Simplified simulation prototype demonstration**. *(B. Haut)*
A demonstration of a prototype performing simplified dynamic simulation will be presented. This prototype will be used to illustrate the various effects of the parameters introduced in the previous lecture and the trade-off which has to be made between accuracy and computation.

16:30 -16.40 **Closing remarks** *(I. Erlich)*

7. Course presenters

Prof. Thierry Van **Cutsem** graduated in Electrical-Mechanical Engineering from the Univ. of Liège (Belgium), where he obtained the Ph.D. degree and he is now adjunct professor. Since 1980, he has been with the Fund for Scientific Research, Belgium, of which he is now a Research Director. His research interests are in power system dynamics, stability, security, simulation and optimization. He collaborates with several transmission system operators. Among some 160 publications, he co-authored a book on Voltage stability of electric power systems. He is a Fellow of the IEEE, and Vice-chair of its Dynamic Performance Committee.

Prof. Pascal Laurent is a Professor at Ecole Centrale Paris and responsible of teaching Applied Mathematics and Numerical Methods at the ECP. He is graduated as from the Ecole Centrale Paris (1973) and obtained his PhD in Mathematics at the Université Paris VII (1980). With a background in engineering, applied mathematics, and computer science, Pascal Laurent is currently working on the numerical part of the Pegase project.

Prof. Istvan Erlich (1953) received his Dipl.-Ing. degree in electrical engineering from the University of Dresden/Germany in 1976. After his studies, he worked in Hungary in the field of electrical distribution networks. From 1979 to 1991, he joined the Department of Electrical Power Systems of the University of Dresden again, where he received his PhD degree in 1983. In the period of 1991 to 1998, he worked with the consulting company EAB in Berlin and the Fraunhofer Institute IITB Dresden respectively. During this time, he also had a teaching assignment at the University of Dresden. Since 1998, he has been Professor and head of the Institute of Electrical Power Systems at the University of Duisburg-Essen/Germany. His major scientific interest is focused on power system stability and control, modeling and simulation of power system dynamics including intelligent system applications. He is a member of VDE and senior member of IEEE.

Prof. Frédéric Magoulès is a Professor at Ecole Centrale Paris and leads the High Performance Computing group at the Applied Mathematics and Systems laboratory. He graduated with a B.Sc. in Engineering Sciences in 1993, an M.Sc. in Applied Mathematics in 1994 and an M.Sc. in Numerical Analysis in 1995, from Université Pierre & Marie Curie. He received his Ph.D. in Applied Mathematics from Université Pierre & Marie Curie in 2000. He then post-doc'ed and taught there for one year, as Assistant Professor of Numerical Analysis, prior to joining Université Henri Poincaré in 2000 as an Assistant and Associate Professor of Applied Mathematics and Engineering. He received his HDR (Habilitation a Diriger des Recherches) from Université Pierre & Marie Curie in 2005. With a background in engineering, applied mathematics, and computer science, and consulting experience with industry and national laboratories, Frédéric Magoulès works at the algorithmic interface between parallel computing and the numerical analysis of partial differential equations.

Bertrand Haut was born in Belgium in 1980. He graduated as Civil Engineer in 2003 and obtained his PhD in Applied Mathematics at the Université catholique de Louvain in 2007. Since 2007 he’s working at Tractebel Engineering SA in the power system consulting service. He is currently responsible for the Time Domain Simulation work package of the PEGASE project.

Patrick Panciatici graduated from the Ecole Supérieure d’Electricité (France) in 1984. He joined EDF R&D in 1985, managing EUROSTAG project and CSVC project. He joined RTE in 2003 and participated in the creation of the department “Methods and Support”. He is the head of a team which develops real time and operational planning tools for RTE and ensures operational support on the use of these tools. Member of the R&D ENTSO-E Working Group. RTE’s representative in PSERC and several European projects (PEGASE, OPTIMATE, TWENTIES, etc.).

8. Travel information

The course venue is the BA building of the University of Duisburg-Essen, Bismarckstrasse 81, D-47057 Duisburg; it is located relatively close to Duisburg main railway station (see maps below).

8.1 Transport link from airport *Düsseldorf International* (DUS) to *Duisburg Hbf* (Duisburg main station)

The following trains are going from the airport train station *Düsseldorf Flughafen* to *Duisburg Hbf* (main station of Duisburg):

RE 1	every hour from 05:28 am	8 min	Terminal Stop: Paderborn
RE 2	every hour from 06:14am	8 min	Terminal Stop: Muenster
RE 3	every hour from 04:53am	10 min	Terminal Stop: Hamm
RE 5	every hour from 07:10am	8 min	Terminal Stop: Emmerich
RE 6	every hour from 07:02am	8 min	Terminal Stop: Minden
S 1	every 20 minutes a day	22 min	Terminal Stop: Dortmund

The Regional Express (RE) is the cheapest and fastest connection from the airport Düsseldorf to the city centre of Duisburg.

Fares:
At ticket machines you have the choice of three adult (ger. “Erwachsen”) tickets: A one-way-ticket, a day-ticket for one person and a group-ticket for 4 persons and a day.

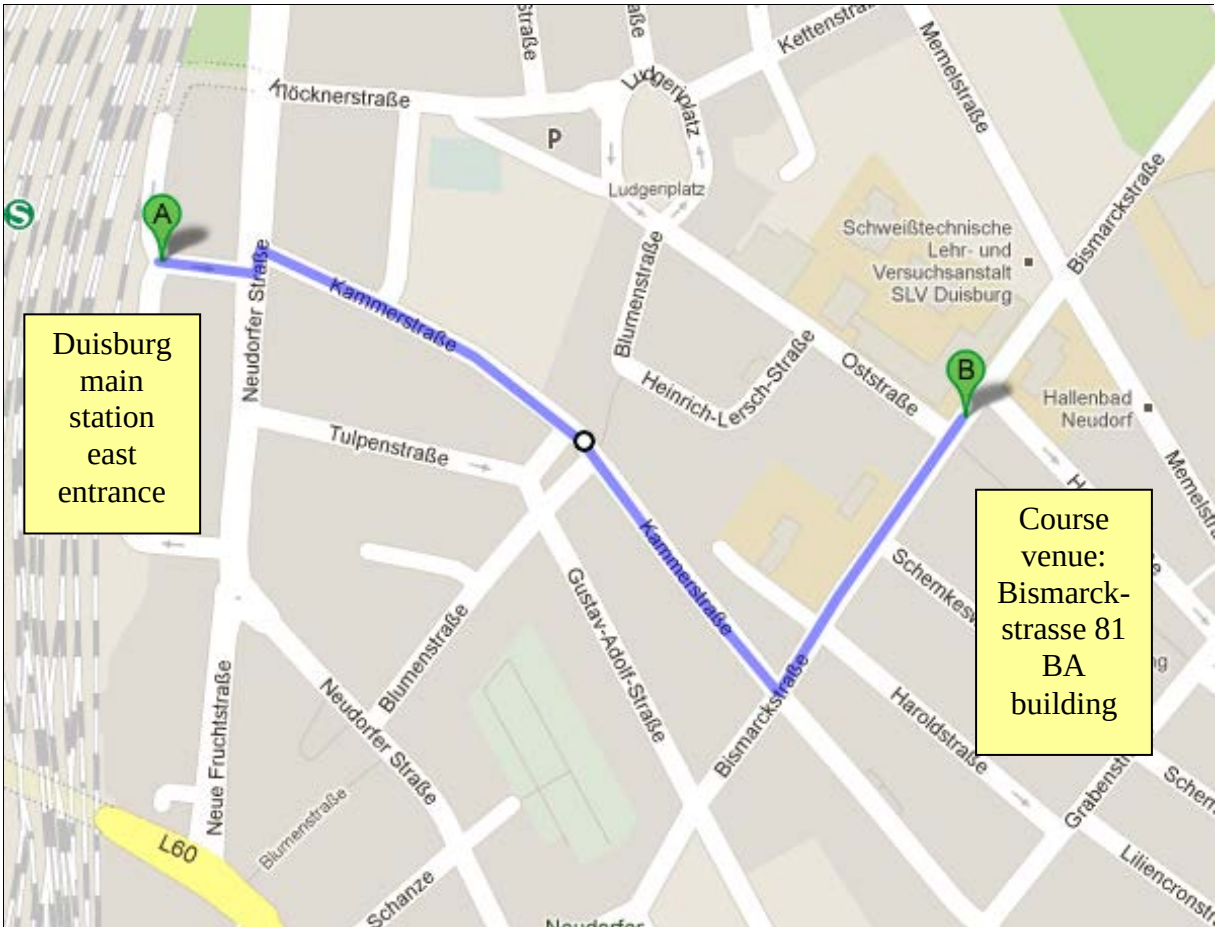
The tariff-zone (ger. “Preisstufe”) for the link to *Duisburg Hbf* is B.

One-way-ticket	B	4,90 €
Day-ticket	B	11,30 €
Group-ticket	B	17,30 €

The connection between the airport terminals and the train station *Düsseldorf Flughafen* is the SkyTrain of the airport *Düsseldorf International*. For more information see:
http://www.duesseldorf-international.de/dus_en/b_skytrain

Taxi Düsseldorf Airport Terminal to Duisburg city: approx. 40 €.

8.2 Way from *Duisburg Hbf* <u>*Ostausgang*</u> (Duisburg main station <u>east entrance</u>) to course venue (850 m walking): see map below. Alternative: taxi (departing from <u>east entrance</u>), approx. 5 €.



9. Accommodation

Recommended Hotels:

Hotel Regent

Dellplatz 1-3

47051 Duisburg

http://www.hotel-regent.de

Rooms approx. € 84

Grand City Hotel Duisburger Hof)

Opernplatz 2

47051 Duisburg

Distance to the University: approx. 2 km

http://www.grandcity-hotel-duisburger-hof.de/

Rooms approx. € 95

Mercure Hotel Duisburg City

Landfermann Strasse 20

47051 Duisburg

http://www.mercure.com/de/hotel-0743-mercure-hotel-duisburg-city/index.shtml

Rooms approx. € 73

Hotel Ibis

Mercatorstrasse 15

47051 Duisburg

Rooms approx. € 73

http://www.ibishotel.com/de/hotel-0846-ibis-duisburg-city/index.shtml

Any other hotel:

http://www.hotel.info/homepage.aspx?lng=SV&co_cpn=579

Please make sure to book your rooms in due time.

10. Organisation and contacts

10.1 Course fees:

Fees for three-day course:

- 367.5 Euro for attendees from member universities of EES-UETP
- 900 Euro for attendees from non-member universities of the EES-UETP
- 1500 Euro for attendees from non-member industrial enterprises of the EES-UETP

Course fees include lectures, course aids (lectures on CDs, leaflets, brochures, etc.) coffee breaks, lunches and course dinner.

1.2 Payment

Attendees make their payments to “Duisburger Universitaetsgesellschaft”

Bank institute: Sparkasse Duisburg

Account number: 0209 000 488

BLZ: 350 500 00

BIC: duisde33XXX

IBAN N: DE02350500000209000488

Notes:

- Please, urgently state the remark “**Kto.-Nr. 91618 – EES-UETP course**” on the bank payment form.
- Participants have to provide course organisers with the proof of course fees payment (i.e. invoice) by fax no later than 1 week before the course date.

10.3 Dinner

On the 21st of June 2012, a course dinner will be held at a restaurant in the city. Further information will be provided during the first morning session. Please inform Mrs Treutler (ean@uni-due.de) if you will be attending.

10.4 Contacts

Course Leader:

Prof. Dr.-Ing. Christian Rehtanz
Technische Universität Dortmund
Institute of Energy Systems, Energy Efficiency and Energy Economics
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Local Organization (Duisburg):

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Ph.: + 49 203 379 3222

11. Registration form (to be returned by June 1st, 2012 latest)

(please reply to fax: +49 203 379 2749 or email: hannelore.treutler@uni-due.de)

Name		
Surname		
Position in the company (university, etc.)		
Main activity		
Contact address		
Contact phone number(s)		
FAX		
E-Mail		
Name, address and main activity of the company (university, etc.)		
Is the company a member of EES-UETP		
Is invoice required	YES	NO
Dinner June 21, 2012	YES	NO