A computer laboratory-based course covering power system transients from introductory to advanced levels

Analysis of Transients in Power Systems

May 5–9, 2014
Madison, Wisconsin

Essential information for:

- Power system analysts
- Transmission engineers
- Substation engineers
- Wind generation analysts
- Researchers
- Consultants

Included With the Course

- Understanding power system transient phenomena
- Conducting practical power system studies
- Assessing the validity of results
- Modeling power system equipment
- Presenting EMTP-RV as a simulation tool

With the participation of Powersys Solutions

Enrollment is limited to 20 students. Enroll early!

You will receive a copy of the new textbook:


Please route this brochure to colleagues who would also benefit by attending.
Analysis of Transients in Power Systems
May 5–9, 2014 in Madison, Wisconsin

Course Highlights
- Introduction to EMTP-RV using examples
- Transmission and distribution case studies
- Power system stability studies, electromechanical oscillations
- Insulation coordination of a 230 kV transmission system
- Insulation coordination of a 230 kV GIS
- Synchronous and asynchronous machine models and associated controls
- Distribution system analysis
- Power quality studies
- HVDC systems
- Wind generation studies

Course Background
Electromagnetic transients exist in power systems in many forms. They span the range from switching and lightning-induced traveling waves to power electronics systems to power quality to wind power generation. The accepted analysis tool for studying these phenomena is the Electromagnetic Transients Program (EMTP). Because of its worldwide use, it is generally considered to be the standard analysis tool.

In the late 1970s the need to formally educate EMTP users was recognized, and the University of Wisconsin–Madison began to offer summer short courses in the use of EMTP. This course continues our mission of offering high-quality instruction in topics of importance to power industry professionals.

New Textbook Provided
Included with the course is a copy of the new textbook
*Power System Transients: Theory and Applications* by Akihiro Ametani, Naoto Nagaoka, Yoshihiro Baba, and Teruo Ohno (CRC Press, 2014). This book describes the transient phenomena unique to electric power systems and how they are analyzed in EMTP-type computer programs.

Course Objective
This course will provide beginning and intermediate students a good hands-on experience on the analysis and modeling of power system transients. The course is based on the usage of EMTP-RV for demonstrating concepts and teaching through practical problem cases. It contributes significantly to the simplification of complex power system studies and to the visualization of complex concepts.

Computer Exercises
Class lectures will be coordinated with computer exercises using EMTP-RV. We will provide classroom computers, or if you have EMTP-RV on your laptop (Windows 7) you may bring it. Students will receive time-limited (30 days) access to the current version of EMTP-RV. For more information on the EMTP-RV software package, please visit [www.emtp.com](http://www.emtp.com) or [Powersys Solutions](http://www.powersys-solutions.com).

Who Should Attend
Engineering personnel familiar with the basics of electric power system analysis who need to get more in-depth knowledge of the analysis and simulation of power system transients in areas including:
- Insulation coordination of HV substations and transmission lines
- Rotating machines dynamics
- Application of power electronics and associated controls in power systems
- HVDC and FACTS equipment
- Distribution system and power quality studies
- Wind power generation and interface issues

Attendees with a limited understanding of power system transients will find that the case study approach will introduce the various families of transients in a manner that develops an in-depth understanding of the phenomena.

Attendees with a more detailed background in power system transients will find that this course will augment their knowledge by providing extended case study exercises to explore. Users of any EMTP-type program will benefit by increasing their knowledge of transient analysis and simulation.

Prior exposure to and experience with the EMTP is not required. It is expected that students are familiar with fundamental concepts of electric power systems including real and reactive power and major equipment found in electric power networks.

Course Faculty
**Jean Mahseredjian** is currently a Professor at École Polytechnique de Montréal. Mahseredjian brings with him more than 20 years of research and development experience, having spent 17 years at the Institut de Recherche d’Hydro-Québec (IREQ) specializing in electromagnetic transient simulation and analysis. He is the creator and main developer of EMTP-RV. Additionally, he served as chairman of the International Conference on Power Systems Transients (IPST 2005) in Montreal and was technical co-chairman of IPST 2007 in Lyon, France.

**Doug Mader** is Director of IT Infrastructure and Enterprise Services at Entergy Services Inc., New Orleans, Louisiana. Mader began his career at the Nova Scotia Power Corporation. During his career at NSPC he rose to the position of Vice President of Engineering of NS Power Services. He moved to Entergy Transmission Business Inc in June of 1998 as Director of Value Engineering, and in 2000 took over responsibility for all Transmission Business Engineering, Project Management, and Construction functions. In October 2007 he was appointed Director of IT Infrastructure and Enterprice Services. Mader has been involved in Electromagnetic Transients Simulation for 30 years and has been a faculty member in numerous EMTP courses over this period.

**Ilhan Kocar** is a Professor at École Polytechnique de Montréal. Kocar was project engineer for Aselsan Electronics Inc., Ankara, Turkey between 1998 and 2004. He worked as an R&D Engineer for CYME International T&D, St-Bruno, Quebec from 2009 to 2011. He joined the faculty at École Polytechnique de Montréal in 2011 where he develops tools for the analysis and simulation of power systems. He works closely with electric distribution utilities and is in active collaboration with companies in the power system software business.

Program Director
**Willis Long** is Professor Emeritus, Department of Engineering Professional Development and Department of Electrical and Computer Engineering, University of Wisconsin—Madison. His principal research interests are HVDC power transmission and the application of power electronics equipment in power systems. He is a Life Fellow of IEEE and recipient of the Uno Lamm HVDC Award and the CIGRE (Paris) Technical Committee Award.
Course Outline

Day 1
1. Introduction to the Program
   • Welcoming remarks
   • What you can expect to learn
   Willis Long
2. Theoretical Backgrounds on Power Systems and Transients
   • Theoretical analysis methods
   • The range of problems and frequencies: lightning, switching, and temporary overvoltages; electromechanical transients
   Jean Mahseredjian
3. Introduction to EMTP-RV and EMTP Works Using Examples
   • Overview: devices, pins, and signals
   • Power and control devices
   • Basic scripting techniques
   Jean Mahseredjian
4. EMTP-RV Simulation Options
   • Load flow, steady-state analysis, and initialization
   • Time-domain computations
   • Solution of nonlinear devices
   Jean Mahseredjian
5. Creation and Maintenance of Subnetworks
   • Subnetwork uniqueness, masking, hierarchy
   • Symbol editor
   • Password protection
   Jean Mahseredjian
6. Creation and Maintenance of Libraries
   • Available libraries
   • Searching for devices
   Jean Mahseredjian

Day 2
7. Basic Models: Switches, RLC Branches, Ideal Sources
   Jean Mahseredjian
8. Simulation of Control Systems
   • Measuring devices: power, voltage, current
   • Periodic meters, transformation functions
   • User-defined modeling
   • Examples: mean-value model, measuring power with variable frequency, variable inductance mode
   Jean Mahseredjian
9. Switching Device Models
   • Simulation of power electronics devices
   • Power converters and switching devices
   Jean Mahseredjian
10. Input Impedance Computation
    Jean Mahseredjian
11. Transmission/Distribution Line and Cable Models
    • Theory and available models
    • Pi-section, constant parameter model, frequency dependent models
    • Corona model
    • Application examples
    Jean Mahseredjian
12. Three-phase Power-flow
    • Methodology and setup options
    • Initialization
    Jean Mahseredjian
13. Transformer Models
    Jean Mahseredjian

Day 3
14. Synchronous and Asynchronous Machine Models and Related Controls
    • Case setup, controls, and initialization
    Jean Mahseredjian
15. The Study of a Complete System
    • From load-flow to steady-state to time-domain
    • Switching transients
    • Temporary overvoltages
    Jean Mahseredjian
    • Exciter, governor and stabilizer models
    • Load model designs and applications
    • Transmission case study
    • Synchronous machine synchronization
    Jean Mahseredjian
17. Statistical Analysis Methods
    Jean Mahseredjian
18. IEEE-34 Bus Distribution Test Case Study
    Jean Mahseredjian
19. Wind Generation and Applications
    Jean Mahseredjian
20. Quick Overview of Distribution Systems: Components, Structure, and Configurations
    Ilhan Kocar

Day 4
21. Steady State Analysis of Unbalanced Distribution Systems
    • Multiphase load flow, short circuit, and fault flow
    • Study of IEEE distribution test feeders and assessment of errors due to topological assumptions
    Ilhan Kocar
22. DG Integration Studies: Solar Panels
    • Circuit based models and average models
    • Protection strategies
    • Control options
    • Impact studies: harmonics, voltage stability, transients, short circuit contribution
    • Interaction with network protectors in grid and isolated network configurations
    Ilhan Kocar
23. HVDC Transmission, Wind Generation
    Jean Mahseredjian

Day 5
24. Insulation Coordination Principles
    • Voltage stresses within the system
    • Power frequency insulation and pollution
    • Lightning, switching, and temporary overvoltages
    • Lightning arrester selection
    • Insulation coordination methodologies
    Doug Mader
25. Insulation Coordination of a 230 kV Transmission System
    • System setup
    • Power-flow and steady-state stability of the system
    • Statistical switching studies and line insulation
    • Temporary overvoltages, usage of line arresters and reclosing resistors
    • Ferroresonance and harmonic resonance
    • Lightning protection of substations
    Doug Mader

Day 26
26. Practical Power System Studies
    • Insulation coordination of a 230 kV GIS
    • Transformer and capacitor bank switching
    • Temporary overvoltage cases - load rejection, self excitation, etc.
    • TRV studies
    • Breaker failure analysis with detailed arc model
    Doug Mader
### Personal Information
(Please print clearly.)

<table>
<thead>
<tr>
<th>Name</th>
<th>________________________________________________________________</th>
</tr>
</thead>
<tbody>
<tr>
<td>Title</td>
<td>________________________________________________________________</td>
</tr>
<tr>
<td>Company</td>
<td>______________________________________________________________</td>
</tr>
<tr>
<td>Address</td>
<td>_______________________________________________________________</td>
</tr>
<tr>
<td>City/State/Zip</td>
<td>____________________________________________________________</td>
</tr>
<tr>
<td>Phone (______)</td>
<td>Fax (______)</td>
</tr>
<tr>
<td>E-mail</td>
<td>________________________________________________________________</td>
</tr>
</tbody>
</table>

### Course Information

**Enrollment is limited to 20 students. Enroll early!**

- Please enroll me in **Analysis of Transients in Power Systems**
  - Course #P017
  - May 5–9, 2014 in Madison, Wisconsin
  - Fee: $2295
- I cannot attend. Please send me information on related courses.

### Course Schedule

**Registration and course will be held at**
The Pyle Center
702 Langdon Street
Madison, WI

<table>
<thead>
<tr>
<th>Day 1</th>
<th>7:45 a.m. to 8:00 a.m.</th>
<th>Registration</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>8:00 a.m. to 5:30 p.m.</td>
<td>Class</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Day 2</th>
<th>8:00 a.m. to 5:30 p.m.</th>
<th>Class</th>
</tr>
</thead>
<tbody>
<tr>
<td>Day 3</td>
<td>8:00 a.m. to 5:30 p.m.</td>
<td>Class</td>
</tr>
<tr>
<td>Day 4</td>
<td>8:00 a.m. to 5:30 p.m.</td>
<td>Class</td>
</tr>
<tr>
<td>Day 5</td>
<td>8:00 a.m. to 3:00 p.m.</td>
<td>Class</td>
</tr>
</tbody>
</table>

Midmorning and midafternoon refreshment breaks and noon lunch will be provided every day.

### Additional Enrollees

<table>
<thead>
<tr>
<th>Name</th>
<th>________________________________________________________________</th>
</tr>
</thead>
<tbody>
<tr>
<td>Title</td>
<td>________________________________________________________________</td>
</tr>
<tr>
<td>E-mail</td>
<td>________________________________________________________________</td>
</tr>
</tbody>
</table>

### Billing Information

- Bill my company
- P.O. or check enclosed (Payable in U.S. funds to UW – Madison)

**Cardholder's Name**

| Card No. | _______________________________ |
| Expires | __________ |

**UW#**

From mailer panel.

### Need to Know More?

Call toll free **800-462-0876** and ask for

**Program Director:**
Willis F. Long
willis@engr.wisc.edu

**Program Associate:**
Debbie Benell
benell@engr.wisc.edu
or e-mail custserv@epd.engr.wisc.edu

**General Information**

**Fee of $2295 Covers** Notebook, textbook Power System Transients: Theory and Applications, other course materials, EMTP-RV access, break refreshments, lunches, and certificate. We do not publish proceedings. Course materials are distributed only to participants.

**Cancellation** If you cannot attend please notify us by April 28, and we will refund your fee. Cancellations received after that date and no-shows are subject to the full fee. You may enroll a substitute at any time before the course starts.

**Location** The Pyle Center, 702 Langdon Street, Madison, WI. Phone messages: 608-262-1122.

**Earn Continuing Education Credit** By participating in this course, you will earn 30 Professional Development Hours (PDH) or 3.0 Continuing Education Units (CEU).

### Accommodations

We have reserved a block of guest rooms (rates starting at $89, including continental breakfast) at The Lowell Center, 610 Langdon Street, Madison, WI. Reserve a room online at epd.engr.wisc.edu/lodgingP017 or call 866-301-1753 or 608-256-2621 and indicate that you will be attending this course under group code ATPS. Room requests after April 5 will be subject to availability. Other fees and restrictions may apply.

We have reserved a second block of guest rooms (rates starting at $118, including shuttle) at The Madison Concourse Hotel and Governor’s Club, One West Dayton Street, Madison, WI.

Reserve a room online at epd.engr.wisc.edu/lodgingBP017 or call 800-356-8293 or 608-257-6000 and indicate that you will be attending this course under group code 325180. Room requests after April 13 will be subject to availability. Other fees and restrictions may apply.

**Enrollment is limited to 20 students. Enroll early!**