

T&D General Systems Subcommittee  
Practical Aspects of Ferroresonance WG  
Pittsburg, Pennsylvania, Convention Center, Room 329  
Tuesday, July 22, 2008, 10:00-12:00

## Meeting Minutes

### Participants:

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### Working Group Officers:

Bruce Mork, Michigan Tech University, is the chair of the WG. David Jacobson, Manitoba Hydro, is co-chair and secretary.

### Discussion:

- The minutes from the 2007 WG meeting in Tampa were reviewed and accepted.
- Minutes and working group documents can be downloaded from:  
[http://www.ece.mtu.edu/faculty/bamork/FR\\_WG/](http://www.ece.mtu.edu/faculty/bamork/FR_WG/)
- A General Systems Subcommittee website is being created by Brian Johnson and will be modified to include a link to the above website. The existing website is out-of-date: <http://grouper.ieee.org/groups/td/gensys/>
- **CIGRE collaboration**
  - Cigre WG C4.301 is putting together a document on insulation coordination and lightning arresters. Lubomir Kocis (Head of R&D, EGU HV Lab, Czech Republic, [kocis@egu-vvn.cz] ) is leading the writing of a section related to ferroresonance. The direction of the work right now has a fair bit of overlap with our work. However, they are in the beginning stages.
  - Michel Rioual has contributed to the document and met with Lubomir at the IPST meeting in Lyon.
  - **Action:** David Jacobson and Michel will meet with Lubomir at the Cigre Paris meeting in August to discuss the best way for the groups to collaborate. August 25, 2008 notes
    - David provided some written comments on the Cigre document.

- The report should focus on potential insulation coordination aspects of ferroresonance and provide guidelines and recommendations.
- Corona could also be considered depending on the overvoltage level.
- A review of utility practices of overvoltage vs. risk could be considered. EDF has a method.
- Surge arresters need to be designed to withstand expected overvoltage magnitude and duration.
- What types of overvoltages are expected during system blackstart restoration?
- Cigre group C4 may have to develop new terms of reference for a new working group.
- There was agreement to coordinate work and jointly review each others documents.

- **Working Group document**

- David Jacobson gave a status report on the document. Very little progress has been made since the last meeting. The biggest issue seems to be the different software versions of the contributions (i.e. Framemaker and Word). David will attempt to convert all contributions to Word and send out the Chapters individually for review. The initial review will be done by the core working group members: David Jacobson, Bruce Mork, Michel Rioual, Reigh Walling and Juan Martinez.
- Individual assignments of the special publication were reviewed and reconfirmed.
- Conference calls or a monthly webex was suggested as a way to gather comments and keep contributions coming in between annual meetings.

- **Technical Presentations**

- Bruce presented information related to voltage magnification from capacitor bank switching and sustained harmonic inrush from a black start field test.
- Michel presented a case example where ferroresonance was experienced in a wind plant transformer.
- Both Bruce and Michel will provide writeups of these examples for the working group document.

- **Notes from July 22 General Systems Subcommittee meeting**

- Working group document is planned on being published as an IEEE special publication in 2009.
- There are no plans for a panel or tutorial in 2009 as the group wants to focus on the main document.

- Once the document is complete, it may lead into one or two IEEE papers.
- There is a desire to expand the scope of the group to tackle additional topics such as:
  - Advanced Methods of Ferroresonance Analysis.
- Bruce and David need to work on some Terms of Reference for any new groups and present to the Subcommittee.

### **WG Special Publication assignments**

- Foreward/Executive Summary – Bruce Mork/David
- 1. Introduction
  - What is Ferroresonance? – David Jacobson/Bruce Mork
  - How does it impact us?-Bruce Mork
  - Typical Waveforms and Overvoltages-Bruce/David/Michel
  - Nonlinear Behaviour, bifurcations-David Jacobson
- 2. Detailed Summary of Literature Search
  - Historical Background & Major Milestones -David/Juan/Michel
  - Basic Circuit Types Susceptible to Ferroresonance-David Jacobson/Juan/Michel
    - Literature summary of distribution systems-Dan Durback/David Smith (Bruce will contact)
  - Basic Mitigation Techniques-David Jacobson
- 3. Catalog of Ferroresonance Scenarios and Mitigation
  - Distribution Systems (< 60 kV)
    - Examples of Ferroresonance-Roger Dugan
    - Ferroresonance in Low-Loss Distribution transformers-Reigh Walling
    - Ferroresonance in a Cable Fed transformer- Francisco De La Rosa
    - Ungrounded delta tertiary – Gary Kobet
    - Case Studies – Gene Lindholm
    - Amtrack rail – Dan Durback
    - Cost of Mitigation Options- Mort Knodaie
  - Transmission Systems (> 60 kV)
    - Open-Delta PT-David Jacobson
    - 230 kV Transformer/grading capacitor-David Jacobson
    - 345 kV VT/grading capacitor-Todd Sarkinen or Bruce Mork
    - Transformer Terminated Double-Circuit Line-David Jacobson and Albert Keri
    - Capacitor Voltage Transformer-David Jacobson
    - Energize 400 kV transformer from isolated generator. Practical guidelines on line length and short circuit level to avoid quasi-periodic oscillations-Michel Rioual/Kieny
  - Summary: Engineering Forensics, Identifying Ferroresonance, Symptoms, Damage-David/Bruce

- 4. Things that are NOT Ferroresonance
  - TOV Summary-Bruce Mork/David Jacobson
    - Refer to types described in IEEE TOV task force report, 1990
    - Cigre paper 33-210
  - EDF TOV Example-Michel Riouale
  - Voltage Magnification (cap bank switching)-Bruce
  - Sustained Harmonic Inrush-Bruce Mork/Roger Dugen
  - Shunt reactor resonance-David Jacobson
  - Switch Restriking-David Jacobson
  - Misinformation in the literature-Bruce Mork (e.g. Wikipedia)
- 5. Introduction to Modeling, Simulation, Parameters
  - Introduction to ferroresonance modelling-Bruce Mork/Juan Martinez
    - Include key points from low frequency modeling chapter (TP-133-0)-David
    - What parts of the network are critical to model (e.g. losses, stray capacitance/cable capacitance, transformer impedance and saturation)
    - Are there simple rules of thumb - Michel
  - Simulation Tools (compare PSCAD/EMTP on a benchmark case)-Bruce/Juan/David
  - Model Parameters –Bruce/Juan
    - Where do parameters come from?
    - Are special transformer tests needed (e.g. inrush test)?
    - How should losses be measured?
  - Introduction to Advanced Modeling (optional)
    - Duality based modeling-Juan Martinez
    - Iron-core loss modeling-Noel Janssens
- 6. Conclusions
  - Should include general recommendations on preferred connections, operating strategies, how to avoid ferroresonance in the design stage or mitigate. The cost of mitigation could be included. David/Bruce
- 7. Appendices
  - Ferroresonance Literature Review-David Jacobson