T&D General Systems Subcommittee

Practical Aspects of Ferroresonance WG

Palais des Congres, Montreal, Room 520a

Tuesday, June 20, 2006, 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 2005 WG meeting in San Fransisco were accepted without review.
- Minutes and working group documents can be downloaded from: 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.

- **Technical Presentations**
- Dan Durbak presented results from a past study he performed for Amtrak.
    - Majority of locomotives are diesel. Problem experienced with an electric train on the east coast. Problems experienced with 25 kV transformers after de-energization. The transformers were capacitively coupled to an energized 25 kV feeder (i.e. the system was 2-phase).
    - Simulations showed a high level of sensitivity to the simulation time step.
    - Several types of mitigation were tried including adding more load to the voltage transformers. The solution that ended up working was to add a saturable reactor on the secondary with a loading resistor. The knee point of this reactor's saturation curve was about 80% of the main transformer.

- Bruce Mork presented a case he investigated for Xcel Energy.
    - Two out of three wound potential transformers failed at Xcel's 345 kV Red Rock station. The problem was attributed to excessive grading capacitance across the open circuit breakers. Xcel plans on replacing the wound PTs with ones that have a higher knee point. An interim solution that is being used is to connect the PTs in open delta with a loading resistor across the open point. The ferroresonance is period-1, however, the loading resistor is effective in eliminating ferroresonance because there are significant zero sequence harmonics (3^{rd}, 6^{th} etc.)

- **Working Group document**
    - David Jacobson gave a status report on the document:
    - Introduction – 60% complete. Need contributions from Bruce.
    - Detailed summary of literature search – 80% complete. Asked for volunteer to write a summary of the salient points from the literature that relate to distribution systems. Dan Durback will ask Dave Smith.
    - Catalog of Ferroresonance scenarios – 50% complete. Case studies have been received from Roger Dugan, Fransisco de la Rosa, Gene Lindholm, Patrick Picher and David Jacobson. Need remaining contributions from Mort Knodaie, Todd Sarkinen, Bruce Mork, Albert Keri, David Jacobson and Michel Rioual. David needs a word file of Reigh Wallings 2003 panel paper.
    - Things that are not Ferroresonance – 10%. Case study received from Michel Rioual. Need remaining contributions from Bruce Mork and David Jacobson.
    - Introduction to Modeling, simulation and parameters – 0%. David will contact Ani Gole to get a copy of the low frequency transients chapter (TP-133-0). Juan volunteered to provide a major contribution once the overall document was in a more mature state.
    - Appendix – literature review – 95%. The annotated bibliography is substantially complete. A few references may be added to bring the document up to date.

- Proposed Work plan
    - The plan is to focus on the WG document and have it complete by December 1, 2006.
        - August 1, 2006 – David will send out a PDF file of the document with contributions received to date
        - September 1, 2006 – deadline for sending in major contributions from working group members: e.g. Case study contributions and "things that are not ferroresonance"

        - October 1, 2006 – David will send out a revised PDF file with the new contributions.
        - Nov. 15, 2006 – deadline for comments and any remaining contributions
        - Dec. 1, 2006 – Final draft will be posted for comments.

- **Notes from General Systems Subcommittee meeting**
    - Working group document is planned on being published as an IEEE special publication in 2007.
    - A panel session or tutorial will be prepared for the 2008 General meeting. A tutorial requires at least one year advance notice. The panel session could be organized to be of a tutorial nature, which wouldn't require as much advance notice for IEEE. The "Development, Experiences and Applications of GIS, GIL and SF6 in Power Systems" panel session was run in this format in Montreal quite effectively.
    - A new name for the working group might be more effective as there are plans to expand the scope of the group to tackle advanced methods of ferroresonance analysis.
        - Proposed change to IEEE Ferroresonance WG with two task forces: TF on Practical Aspects of Ferroresonance, TF on Advanced Methods of Ferroresonance Analysis.
        - A name change needs to be submitted by the chair of the General Systems Subcommittee (Reza Iravani) and voted on by the T&D Committee. Task forces can be created by the WG chairs without approval from the SC chair.
        - David and Bruce will discuss the changes further and discuss with the Working Group. A decision should be made prior to December 2006 in case organization changes are desired for the General meeting in Tampa.
    - The meeting time of the WG was discussed. The current time of 10-12 on Tuesday causes conflict for some members who are participating in other distributed generation groups. A proposal was made to move the General Systems Subcommittee meeting to Wednesday at 5-6 pm. Wednesday afternoon may be a possibility for the ferroresonance meetings. Bruce is working on the Power Globe WG from 1:30-2:30. Perhaps 2:30-3:30 for TF on Advanced Methods of Ferroresonance Analysis and 3:30-5:00 for a joint meeting TF on Practical Aspects/IEEE Ferro WG might work. Bruce and David will discuss and propose a time to Reza Iravani.

WG Special Publication assignments

- Foreward/Executive Summary – Bruce Mork/David
- Introduction
  - What is Ferroresonance? – David Jacobson/Bruce Mork
  - How does it impact us?-Bruce Mork
  - Typical Waveforms and Overvoltages-Bruce/David
  - Nonlinear Behaviour, bifurcations-David Jacobson
- Detailed Summary of Literature Search
  - Historical Background & Major Milestones -David Jacobson
  - Basic Circuit Types Susceptible to Ferroresonance-David Jacobson
    - Literature summary of distribution systems-Dan Durback/David Smith
  - Basic Mitigation Techniques-David Jacobson
- 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
- 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

- 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)
  - Simulation Tools-Bruce Mork
  - 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
- 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
- Appendices
  - Ferroresonance Literature Review-David Jacobson