Centre Journal

Volume 11 Issue 5 Summer 2000

Manitoba HVDC Research Centre Inc.

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Damping of Generator Shaft Torsional Oscillations

The Manitoba HVDC Research Centre Inc. has undertaken several studies into damping of torsional oscillations on generator shafts. Although mechanical damping is always present and positive, the electric power system through the generator connection also contributes to damping.

The well known and most severe case is subsynchronous resonance. Here the damping from the electrical system is negative and when it exceeds the positive mechanical damping and remains undetected for some period of time, it results in shaft damage due to metal fatigue. Negative damping may be evident when there are series capacitors in the ac transmission network nearby. Contributions to electrical damping of shaft torsional oscillations are also derived from fast response controllers such as power system stabilizers and nearby dc transmission and FACTS.

How is it possible to evaluate whether their damping contribution is positive (desirable) or negative (undesirable)? During the design stage of a new generator installation, screening tests are possible to determine the level of electrical damping on shaft torsional oscillations. Use is made of the latest technologies available in system simulation with PSCAD/EMTDC V3.

One such test is to firstly, construct a detailed simulation model on PSCAD/EMTDC V3 of the generator under study, its excitation system and power system stabilizer, as well as any dc transmission or FACTS controllers located nearby. It is important to include the details and non-linearities of the controllers, and develop as much precision as the level of data available allows. The higher precision of the simulation, the less chance for surprises after the equipment is in service.

The next step of the test is in simulation, where a frequency scan is undertaken at the air gap of the generator by independently perturbating the speed of the generator. The influence on damping from the generator, its exciter, stabilizer, unit transformer and the power system beyond is detected in the phase lag of the electrical torque in the air gap. If the response of the measured electrical torque lags or leads by 90 degrees or more with respect to the perturbation of rotor speed, then a natural torsional oscillation causing that same deviation of generator speed will be negatively damped.

An example case is a 75 MVA generator radially feeding a voltage sourced converter (VSC) dc transmission line (VSC Transmission is also known as "HVDC Light" by ABB and "HVDC^{Plus}" by Siemens). The observed phase lag of torque with respect to rotor speed over the subsynchronous frequencies of interest were observed in Figure 1 to be consistently less than

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What is in the Inc. ? The Changing Status of the Centre Inc.

I like to read books to my two boys every night before bed, an activity for our mutual enjoyment and development. Their points of view expand with the exciting and wondrous world books bring to them. For us here at the Centre, the last six months have been equally exciting. The staff of the Centre have tackled and surmounted various challenges.

One of the most recent business challenges has been the conversion of the "not for profit" Manitoba HVDC Research Centre, to the regular corporation now called the Manitoba HVDC Research Centre Inc. This change may seem trivial on the surface but in fact, due to Canadian Law, was not. The old Centre had to be completely shut down (this included closing financial records, termination given to staff and the Federal business charter surrendered). At the same time a new Provincial business charter was created (new financial records, business processes created, and staff re-hired) all while business continued without interruption.

What has been the impact to our clients?

Very little. As of February 1, 2000, the Company was incorporated as a wholly owned subsidiary of Manitoba Hydro with the mandate to perform research, develop and market software and technology. Our mission has not changed; the only change is in the way the Centre is governed. The removal of the not-for-profit status lifted many of the restrictions that were placed on the Centre and we look forward to the future fulfilling our mission and improving our clients' positions.

Paul Wilson Managing Director

Interactions Between Distributed Generation and Loads

With distributed generation a reality, there is a possibility adverse interactions will occur between different types of generators and loads connected to the same feeder or electrically close. Loads with poor power quality such as from induction or arc furnaces, large motor drives or pulsating generation may result in interactions or cause flicker in lighting. For example, a diesel generator causes pulsating surges on the network that may interact with lightly damped modes of torsional oscillations of a turbine generator located nearby. A wind turbine exposed to fluctuating wind velocity can generate surges in power.

Is it possible to anticipate the impact of new generation or loads on the distribution system? Is it possible to design ahead of time and ameliorate undesirable effects rather than dealing with the problem after the new load or generation has been installed?

PSCAD/EMTDC V3 can help you examine any possible interactions between loads and generation that may be of concern and provide information to evaluate the alternative solutions before the new expansion of load or generation is brought on-line. Simulation recordings of expected system voltage can be made and played back in real time through the Real Time Playback (RTP). The simulated voltage generated from RTP is amplified and fed into standard lighting fixtures and measurements of flicker can be taken to ensure IEEE Flicker Standard 141 or equivalent is maintained under all possible contingencies.

Dennis Woodford
Goran Ivkovic

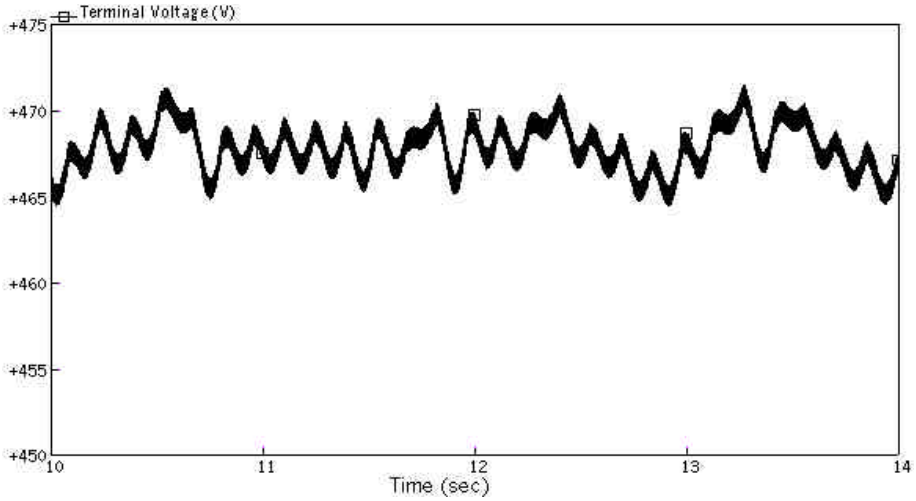


Figure 1. Simulated diesel generator terminal voltage while undergoing a continuous cylinder misfire.

RTP used to simulate and record voltages and currents for real time playback.

Digital playback signals are converted to analog.

Analog signals are amplified to load levels.

Load voltages are connected to load and flicker or power quality measurements are taken and tested for acceptability

Collaborative Research : On-line Monitoring of HV Breakers

The Manitoba HVDC Research Centre Inc. is completing a four year collaborative research field evaluation project into On-line Condition Monitoring Systems for 230 kV Breakers. This project was uniquely structured , with nine international participants purchasing shares of the research project. Under the project agreements the detailed results of this research are closed to the project participants. It has become clear that although on-line monitoring systems hold the promise of reducing maintenance costs and improving overall system reliability, there are many technical issues that the applications of on-line monitoring requires. The Centre and Manitoba Hydro are sponsoring a new on-line monitoring project and is looking for interested utility partners with ABB HLR minimum oil breakers. In co-operation with ABB, this project will implement an ABB OLM monitoring system on a HLR breaker. This breaker has known higher maintenance costs. The objective of the research is to apply on-line monitoring technology to reduce maintenance and to assist in determining end of life information. This project will include an investigation of using the internet to transfer on-line monitoring data. If you are interested, please contact the Centre at rww@hvdc.ca
Randy Wachal

The Centre is looking for utilities using ABB HLR Breakers interested in Collaborative Research.

Announcing RTP BATCH Mode Operation

RTP now has full Batch mode capabilities to automate your testing requirements.

- Perform multiple tests with no user intervention required.
- Create Batch Test files using PSCAD Multiple Run Feature.
- Synchronous RTP Start Capability allows Batch Power Quality Testing without de-energizing equipment between Test Cases.

RTP Development Team Continues to Enhance RTP Functionality
Making RTP Testing "State of the Art"

Testing Professional:
The RTP system is continually being enhanced and improved. The combination of PSCAD/EMTDC simulation and RTP playback is an extremely versatile and power testing platform. An updated series of Technical Application Notes has been developed to assist the RTP users in using the RTP to meet your testing requirements.
You are invited to download the current version of RTP and try it out. See www.hvdc.ca

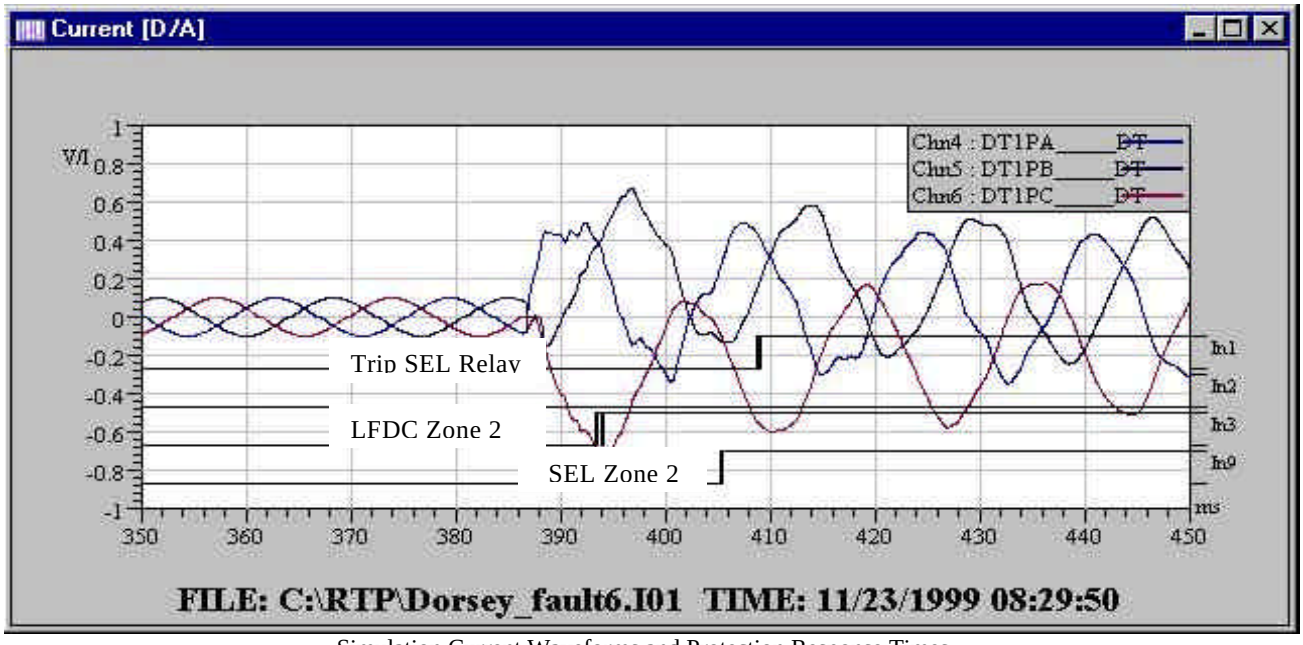
RTP Case Study: Dynamic RTP Relay Testing for Winnipeg -Twin Cities 500kV Transmission Line D602F

The protection system for the D602F 500 kV transmission line was modified. During the pre-commissioning testing, the new relay system was shown to respond to transients produced by the test equipment. The relay testing system introduced transients during the pre-fault data playback and during the transient from state to state. This generated an opportunity for the Real Time Playback (RTP) as it generates a smooth pre-fault waveform and does not produce any transitional transients during the playback of the data-file. As a result, the RTP test system was utilized to continue testing the modified D602F line protection.

Protection Testing Using the RTP
The RTP system has features for both State Simulation and Transient Playback of waveforms. For the D602F protection testing, the transient playback of the data files was utilized. The source of the datafiles can be from either a transient simulation program (PSCAD/ EMTDC, emtp) or from Digital Fault Recorders (DFR). This series of protection testing utilized both simulation datafiles and DFR fault records. Approximately 100 emtp simulations were performed, which generated the required COMTRADE data waveform files. The ability to generate test waveforms in transient simulation allow for a thorough testing of the protection system. Tests can be performed on all types of faults, operating conditions, and system loading. Tests were performed using captured system events from DFR recordings to provide an additional level of confidence that the off-line testing results represents real world

The combination of simulation and off-line dynamic testing was used to verify the robustness of the protection modification. As the AC system and the associated protection continues to increase in complexity, the sophistication of the simulation tools and off-line relay testing will also increase. The RTP test system was successfully utilized to validate a new protection scheme on the series compensated 500 kV D602F transmission line.

Dan Kell / Randy Wachal



Simulation Current Waveforms and Protection Response Times

(Continued from page 1)

90 degrees, thus ensuring that any subsynchronous torsional oscillations will receive positive damping from the electrical network.

As a clear comparison, the same frequency scan test is undertaken for the known subsynchronous resonance case of the IEEE Benchmark for subsynchronous resonance (published by the IEEE in the Transactions on Power Apparatus and Systems, Vol. 96, No. 5, October 1977, pp 1565-1572). Here the electrical torque in the generator air gap exceeds the 90 degree lag or lead of generator rotor speed perturbations for rotor frequencies between 10 Hz to 30 Hz. Any mechanical shaft torsional oscillations within this frequency range will be negatively damped from the ac system.

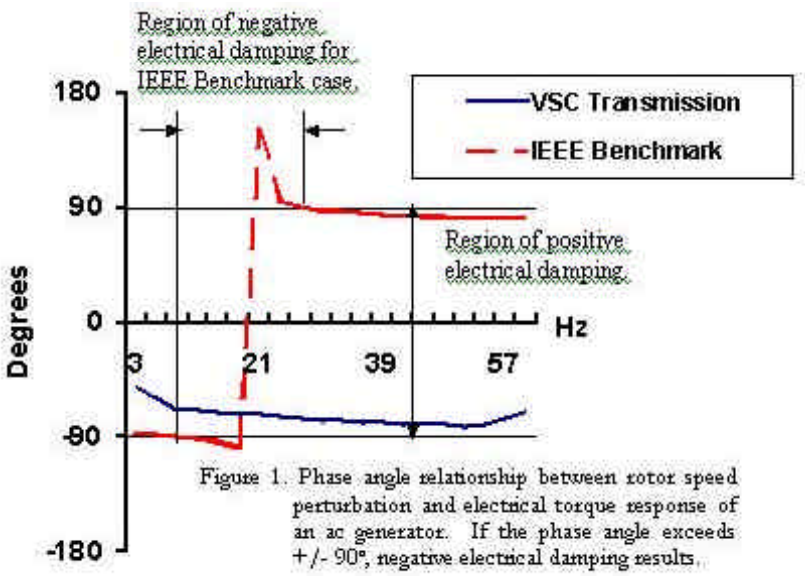


Figure 1. Phase angle relationship between rotor speed perturbation and electrical torque response of an ac generator. If the phase angle exceeds +/- 90°, negative electrical damping results.

From Figure 1, the phase angles between rotor speed perturbations and electrical torque are plotted over the subsynchronous range of interest. The radial VSC Transmission always provides positive electrical damping for this case. It is comforting to know this if contemplating any VSC transmission to feed radially from a generator.

Of course, a detailed examination for any particular project should still be undertaken, and PSCAD/EMTDC V3 is certainly a tool to apply in such a study.

Dennis Woodford / Rohitha Jayasinghe

An Introduction to PSCAD/EMTDC V3 : On-line Manual

This recent manual offers engineering background and support in:

- Transient overvoltages and circuit breaker TRV
- Insulation coordination and surge arresters
- Lightning and fast front surges
- Transmission lines, transformers and generators
- Application of system controls
- STATCOM application and system design

PSCAD EMTDC™

- It is available as a free download in PDF format from our website: http://www.hvdc.ca/main/downloads/pscad_v3/index.html

To download, choose one of the Personal, Education or Commercial Edition download options, use your User Name and Password (or contact us at pscad@hvdc.ca if you don't have them) and download the manual, accompanying example cases and even the latest release of PSCAD/EMTDC Version 3.0.4. The Personal Edition is also free.

IEEE SUMMER POWER Meeting In Seattle

Visit The Centre's Hospitality Suite @ Sheraton Hotel and Towers
Monday - Wednesday, July 17-19 , 2000
From 5:00 pm to 8:00 pm

Centre staff will be presenting hands-on demonstrations of PSCAD V3 and Real Time Playback. We invite you to bring your simulation needs for discussion.

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