

## OSCAR LENNERHAG

Oscar Lennerhag received his M.Sc. in Electric Power Engineering at Chalmers University of Technology, Gothenburg, in 2013, after which he joined STRI in Gothenburg. During his time at STRI he worked with modeling, dynamic and transient studies (with a focus on insulation coordination) as well as power quality measurements and analysis. Since September 2017 Oscar is working as a Specialist at Independent Insulation Group, Sweden. He has extensive knowledge of several simulation tools including PowerFactory, PSCAD, PSS/E and EMTP-ATP.



Oscar is currently pursuing an industrial PhD in cooperation with Luleå University of Technology. He is a member of several CIGRE working groups.

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### MAIN FIELDS OF COMPETENCE

- Transient studies/insulation coordination
  - Temporary overvoltages in systems with long cables/low order resonances
  - Switching overvoltages
  - Lightning overvoltages
- Power quality measurements and analysis
- Modelling and dynamic simulations

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### WORK EXPERIENCE

- 2017 – **Independent Insulation Group Sweden AB**, Göteborg, Sweden  
*Specialist*
- 2013 – 2017 **STRI AB**, Göteborg, Sweden  
*Engineer, Power Systems*  
Employed as a power system engineer. Involved in a range of projects including modelling, transient and dynamic studies as well as power quality measurements and analysis.

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### EDUCATIONAL DEGREES

- 2017- **Luleå University of Technology**  
*Industrial PhD Student*  
Project title: Calculation methods for power systems under large uncertainties

2013                    **Master of Science in Electric Power Engineering**  
 Chalmers University of Technology, Göteborg, Sweden.  
 Thesis: Modelling of VSC-HVDC for Slow Dynamic Studies  
 September 2011 – June 2013

2010                    **Bachelor of Science**  
 Chalmers University of Technology, Göteborg, Sweden  
 August 2008 – June 2010

**MEMBERSHIP OF TECHNICAL COMMITTEES**

CIGRE JOINT WORKING GROUP B1/C4.69 – Recommendations for the insulation coordination on AC cable systems  
 CIGRE WORKING GROUP C4.46 – Evaluation of TOVs in Power Systems due to Low Order Harmonic Resonances  
 CIGRE JOINT WORKING GROUP C4/B4.38 – Network Modelling for Harmonic Studies (**Finished, 2019**)

**LANGUAGES**

Swedish (native), English (professional level)

**LIST OF PROJECTS**

2017-	<b>Industrial PhD project</b> Project title: "Calculation methods for power systems under large uncertainties" The focus of the project is to develop new calculation methods for insulation coordination and spread of harmonics that can handle large uncertainties in component data, network configuration etc.
2021-	<b>Technical requirements for power quality</b> Development of technical requirements related to power quality together with a transmission system operator.
2020-	<b>EMT-type simulations for series compensated lines (SOV)</b> Modelling and simulations of series compensated lines in PSCAD.
2020	<b>Network harmonic impedance calculation</b> Network harmonic impedance calculation as input to filter design for new static converters.
2020	<b>Consequences of cablification of transmission networks</b> Summary of possible consequences of cablification of transmission networks
2019-2020	<b>Insulation coordination (LOV)</b> Simulations and analysis of lightning overvoltages in a 220 kV network using PSCAD.
2019-2020	<b>Insulation coordination for wind farms (LOV, SOV)</b> Insulation coordination studies including switching overvoltages and lightning overvoltages in wind farms using PSCAD.

2017-2019	<b>Insulation coordination (TOV, SOV)</b> Insulation coordination studies in PSCAD following the installation of a large amount of cables at transmission level. Studies focused on temporary overvoltages due to low order resonances as well as switching overvoltages.
2019	<b>Resonance analysis</b> Resonance analysis for a network feeding the Swedish railway using PSCAD.
2019	<b>Course in Power Quality</b> Power quality course for a TSO.
2017-2019	<b>Measurements and analysis of harmonics and supraharmonics</b> Measurements and analysis of harmonics and supraharmonics (>2.5 kHz). Measurements were performed at 400 V and 70 kV.
2018-	<b>Wind farm connection studies</b> Including e.g. cable dimensioning, connection requirements, etc. using PowerFactory.
2018	<b>Switching overvoltage (SOV) calculations for 220 kV cable installations</b> Simulations and analysis of switching overvoltages in a 220 kV cable network using PSCAD.
2018	<b>Transient calculations (SOV) in a distribution network</b> Investigation of switching overvoltages following cablification of a distribution network using PSCAD.
2016-2017	<b>Converter interoperability, Cloudgrid</b> Development of different HVDC converter topologies and control system models in PSCAD for interoperability investigations
2016-2017	<b>Ancillary services from a provider perspective, Cloudgrid</b> Investigation of the value of ancillary services provided by different stakeholders
2017-2018	<b>Wind farm connection studies</b> Wind farm connection studies, including cable dimensioning, reactive power compensation and short circuit studies using PowerFactory.
2017	<b>HVDC commissioning measurements</b> Field measurements (power quality) related to the commissioning of an HVDC link.
2016-2017	<b>European Pattern Recognition Project</b> Studies on power regulation by voltage control and hosting capacity in the European research project ERA-NET, European Pattern Recognition - Renewable Energy Impact.
2016-2017	<b>Power quality measurements and analysis</b> Field measurements and analysis of power quality for a railway system following the installation of new static converters.
2016-2017	<b>Dynamic line rating for cables and transformers</b> Study of solutions for dynamic rating for cables and transformers.
2016-2017	<b>Modelling of aggregated loads</b> Methodology verification for TSOs on Modeling of aggregated load for PSS/E Simulation. Includes field measurements at substations at different voltage levels.
2016-2017	<b>Insulation coordination (SOV, TOV) for a long cable connection</b> Insulation coordination studies for the connection of a very long (100 km) HVAC cable to an island. The study investigated switching and temporary overvoltages in PSCAD and investigation of zero miss, including compensation and switching strategies to minimize zero miss.
2016	<b>Model conversion</b> Model conversion of generator and its control from PSCAD to PSS/E.

2016	<b>Wind farm connection study</b> Wind farm connection study, including reactive power compensation and short circuit studies in PowerFactory
2015	<b>Protection testing</b> Primary testing of directional earth fault relays for a railway system. Includes field measurements.
2015-	<b>Guest Lecturer (ongoing)</b> Returning guest lecturer in the areas of HVDC, distribution grids and power quality at Högskolan Dalarna, Borlänge, Sweden.
2015-2017	<b>Insulation coordination (TOV, SOV)</b> Insulation coordination studies in PSCAD following the installation of a large amount of cables at transmission level. Studies focused on temporary overvoltages caused by low order resonances and switching overvoltages. The studies also include analysis of different compensation/switching schemes to minimize the risk for zero miss.
2016	<b>Excitation system modelling</b> Modelling of a generator excitation system in PowerFactory for dynamic studies.
2015	<b>Resonance phenomena in systems with long AC cables</b> Theoretical study regarding resonance phenomena in transmission systems with long cables.
2015	<b>Evaluation of method for emission allocation</b> Evaluation of the method used by a TSO to allocate emission limits to new connections.
2014-2015	<b>Wind farm connection study</b> Wind farm connection study, including modeling in PSCAD (for SOV calculations) and PowerFactory as well as insulation coordination and harmonic studies
2013-2014	<b>Power quality course and permanent measurement program development</b> Power quality course and a report detailing a permanent power quality measurement program for a TSO
2014	<b>Flicker investigation</b> Investigation of flicker originating from an EAF and an evaluation of possible mitigation methods.
2014–2016, 2018-	<b>Conceptual development of Stirling based solar power</b> Conceptual development of Stirling based solar power, including development of converter controls, system modeling and simulations in PSCAD
2013–2014	<b>Voltage variations on the time scale of 1s-10 min</b> A study of voltage variations at different time scales due to an increase of distributed generation. Includes field measurements of voltage variations.

## LIST OF PUBLICATIONS

**O. Lennerhag, M. Bollen**

*A stochastic aggregate harmonic load model*

IEEE Transactions on Power Delivery, 2020

**O. Lennerhag, A. Dernfalk, P. Nygren**

*Supraharmonics in the presence of static frequency converters feeding a 16 2/3 Hz railway system*

International Conference on Harmonics and Quality of Power (ICHQP), Dubai, UAE, 2020

**O. Lennerhag, M. Bollen**

*Springer Handbook of Power Systems – Chapter on Power Quality*

Springer, 2020

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**O. Lennerhag**, R. Rogersten, S. Råström  
*Parallel Resonance Investigation in Stockholm's Future Cablified Transmission Grid: A Prospective Study on Transformer Energization*  
 IEEE Transmission & Distribution, Chicago, USA, 2020

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**O. Lennerhag**, J. Lundquist, C. Engelbrecht, T. Karmokar and M. Bollen  
*An Improved Statistical Method for Calculating Lightning Overvoltages in HVDC Overhead Line/Cable Systems*  
 Energies, 12(16), 3121, 2019. Available: <https://www.mdpi.com/1996-1073/12/16/3121/htm>

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**O. Lennerhag**, M. Bollen  
*Impact of uncertainties on resonant overvoltages*  
 International Conference on Power System Transients (IPST), Perpignan, France, 2019

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**O. Lennerhag**, M. Bollen  
*A power system model for resonance studies*  
 International Conference on Electricity Distribution (CIRED), Madrid, Spain, 2019

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D. Schwanz, M. Bollen, **O. Lennerhag**, A. Larsson  
*Major Impacts on Harmonic Transfers in Wind Power Plants*  
 submitted to IEEE Transactions on Sustainable Energy, 2019

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T. Karmokar, **O. Lennerhag**  
*Simplified approach for investigating overvoltages in DC cables in a ±320 kV symmetrical monopolar HVDC system*  
 International Symposium on High Voltage Engineering (ISH), Budapest, Hungary, 2019

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**O. Lennerhag**, M. Bollen  
*Power system impacts of decreasing resonance frequencies*  
 International Conference on Harmonics and Quality of Power (ICHQP), Ljubljana, Slovenia, 2018

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M. Bollen, S. Rönnerberg, **O. Lennerhag**  
*Påverkan på nätet från stora mängder solkraft*  
 Energiforsk rapport 2018:539, Stockholm, Sweden, 2018

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A. Perez, **O. Lennerhag**  
*Dynamisk belastbarhet för jordkablar (Dynamic rating for cables)*  
 Energiforsk rapport 2017:427, Stockholm, Sweden, 2017

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**O. Lennerhag**, S. Aceby, M. Bollen, G. Foskolos, T. Gafurov  
*Using measurements to increase the accuracy of hosting capacity calculations*  
 24<sup>th</sup> International Conference & Exhibition on Electricity Distribution (CIRED), Glasgow, Scotland, June 2017

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**O. Lennerhag**, G. Pinares, M. Bollen, G. Foskolos, T. Gafurov  
*Performance indicators for quantifying the ability of the grid to host renewable electricity production*  
 24<sup>th</sup> International Conference & Exhibition on Electricity Distribution (CIRED), Glasgow, Scotland, June 2017

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F. Barakou, M. Bollen, S. Mousavi-Gargari, **O. Lennerhag**, P.A.A.F Wouters, E.F. Steennis  
*Impact of load modeling on the harmonic impedance seen from the transmission network*  
 International Conference on Harmonics and Quality of Power (ICHQP), Belo Horizonte, Brazil, October 2016

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M. Bollen, D. Karlsson, **O. Lennerhag**  
*Different fault types and voltage dips in relation to shielding of subtransmission lines*  
 International Conference on Harmonics and Quality of Power (ICHQP), Belo Horizonte, Brazil, October 2016

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N. Etherden, M. Bollen, S. Aceby, **O. Lennerhag**  
*The transparent hosting-capacity approach – overview, applications and developments*  
 International Conference and Exhibition on Electricity Distribution (CIRED), Lyon, France, June 2015

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**O. Lennerhag**, S. Aceby, M. Bollen, S. Rönnerberg  
*Very short variations in voltage (timescale less than 10 minutes) due to variations in wind and solar power*  
 International Conference and Exhibition on Electricity Distribution (CIRED), Lyon, France, June 2015

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**O. Lennerhag**, S. Aceby, M. Bollen, S. Rönnerberg

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*Voltage variations due to wind power and solar power at time scales of 10 minutes and less*  
Nordic Conference on Electricity Distribution System Management and Development (NORDAC),  
Stockholm, Sweden, September 2014

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**O. Lennerhag**, S. Aceby, M. Bollen, S. Rönnberg  
*Spänningsvariationer och intermittent produktion*  
Energiforsk rapport 14:42, Stockholm, Sweden, 2014

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**O. Lennerhag**, V. Träff  
*Modelling of VSC-HVDC for Slow Dynamic Studies*  
Master's Thesis, Chalmers University of Technology, Gothenburg, Sweden, 2013

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