



UNIVERSITÀ DEGLI STUDI DI NAPOLI
FEDERICO II

itee_{PhD}
information technology
electrical engineering



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Nagananthini Ravichandran

Lightning-Produced (Direct Lightning) & Lightning-Induced (Indirect Lightning) Over Voltages – Analytical Formulations and Mitigation Solutions

Tutor: Amedeo Andreotti Co-Tutor: Daniela Proto
Cycle: XXXVII Year: First

MY BACKGROUND

- Master of Engineering in Power Electronics and Drives – Anna University, Tamil Nadu India
- Research group - Power System Group (ING-IND/33) – Sistemi Elettrici per l'Energia
- PhD start date - 01/11/2021 (Academic Year: 2021-2022)
- Scholarship type - UNINA

RESEARCH FIELD OF INTEREST



POWER QUALITY ISSUES

DIRECT AND INDIRECT LIGHTNING EVENTS

NETWORK MODELLING AND MITIGATION SOLUTIONS

SUMMARY OF STUDY ACTIVITIES (1/2)

AD HOC PHD COURSE

- **Matrix Analysis for Signal Processing with MATLAB Examples:** The course provides an overview of some topics in matrix theory together with their intrinsic interaction with an application to signal processing.
- **Statistical data analysis for science and engineering research:** The course provides an overview of the experimental design and data analysis and is intended for PhD students in science and engineering disciplines who need to use statistical methods and data analysis as part of their research
- **Big Data Architecture and Analysis:** The aim of the course is to investigate Big Data methodologies and architectures for supporting several analytics in the health field
- **Machine Learning for Science and Engineering Research:** The course introduces the main topics in machine learning for both supervised and unsupervised approaches with the concept of AI and special attention to Neural networks.
- **Sustainable ship for the energy transition of maritime transport:** The course provides PhD students with the basic and specialist knowledge of ship design and management
- **Operational Research: Mathematical Modelling, Methods and Software Tools for Optimization Problems:** The course teaches how to build mathematical models of optimization problems, to be able to classify models and know the mathematical foundations of algorithmic techniques that allow them to be solved.

SUMMARY OF STUDY ACTIVITIES (2/2)

PHD SCHOOLS

- Lectures on Computational Linguistics June 8 – 10, 2022 [Virtual]: The interdisciplinary nature of the school characterizes two main areas: the humanistic one, characterized by topics related to linguistics and investigations in the field of digital humanities, and the technological one, linked to the topics of computer science, computer engineering and artificial intelligence and cognitive sciences.

COURSES BORROWED FROM MSC CURRICULA

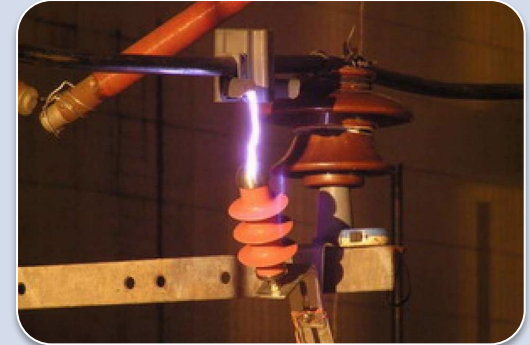
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CONFERENCES/EVENTS ATTENDED

- 20th International Conference on Harmonics & Quality of Power (ICHQP), May 29 – June 1, 2022, Naples [Organizing Committee]
- International Symposium on Power Electronics, Electrical Drives, Automation and Motion (SPEEDAM), June 22 – 24, 2022, Sorrento [Presented a Poster]
- AEIT International Annual Conference, October 3 – 5, 2022, Rome.[Presented a Paper]

RESEARCH ACTIVITY: OVERVIEW (1/4)

PROBLEM IDENTIFICATION



POWER QUALITY ISSUES

Voltage sags
Transients
Temporary interruption
Permanent interruptions

MAJOR CAUSES

Lightning-Induced
Overvoltages
(LIOV)
Lightning-Produced
Overvoltages
(LPOV)

PERFORMANCE IMPROVEMENT

Network Modelling and
Analytical solutions
Cost-Effective
mitigation Solutions

RESEARCH ACTIVITY: OVERVIEW (2/4)

OBJECTIVE

To derive simple (engineering) solutions for LIOV and LPOV assessment and validate them on real electrical networks

Accurate and realistic analytical expression in terms of impulse current excited by an external field.

Analyze the performance with real-time implementation on a real distribution network.

To mitigate the risk of failures and power outages caused by LIOV and LPOV.

Economical and effective solutions to protect the system by optimal location of surge arrester

Implementation of independent or hybrid protection measures using surge arrester, shield wires and underbuilt shield wires

RESEARCH ACTIVITY: OVERVIEW (3/4)

METHODOLOGY



Electro Magnetic Transients Program

- EMTP
- EMTP LIOV
- Protection Devices



Lightning event Probability

- LEMP and transmission line coupling calculation
- Monte Carlo assessment



Probabilistic Multiobjective Optimization

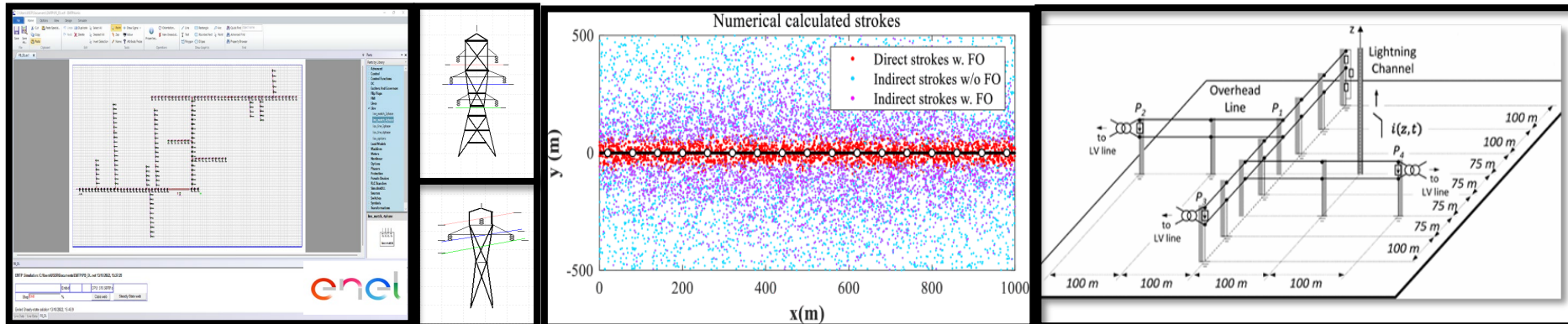
- Estimation of flashover rate and optimal location of surge arresters (GA)
- Decision making approaches



RESEARCH ACTIVITY: OVERVIEW (4/4)

PROGRESS TO DATE

- An existing power network for the optimal location of the protection devices has been identified and implemented in EMTP software to analyze the response to direct and indirect lightning events.
- The LIOV and LPOV on the poles are calculated using MATLAB
- The optimization constraints are analyzed from previous research and the implementation method to minimize the risk of failure and cost is identified.



PRODUCTS

[P1]	D'Orazio, Luigi; Di Felice, Gianluca; Frain, Jean Baptiste; Andreotti, Amedeo; Ravichandran, Naganathini; Gentilini, Ivano; Proto, Daniela; Greco, Antonello; Spitilli, Ludovico “Analysis Of Data Gathered During The Application Of LLPDs On MV Feeder Of E-distribuzione” CIRED 2023 International Conference & Exhibition on electricity Distribution, Rome June 12 – 15, 2023. [Abstract Submitted]
[P2]	A.Andreotti, A. D. Pasquale, M. Pagano, N. Ravichandran and F. Volpe Analysis of Lightning Transients in 2×25 kV Railway Network using EMTP. AEIT 2022 International Annual Conference, Rome, Italy. [Paper Presented]

PRODUCTS

[P1]	Nagananthini Ravichandran, Nagavinothini Ravichandran, Balamurugan Panneerselvam, Comparative assessment of offshore floating photovoltaic systems using thin film modules for Maldives islands, Sustainable Energy Technologies and Assessments, Volume 53, Part A,2022,102490, ISSN 2213-1388, https://doi.org/10.1016/j.seta.2022.102490 . [Article Published]
[P2]	Nagananthini Ravichandran, Amedeo Andreotti, Mario Pagano, Antonio Di Pasquale and Francesco Volpe,” Interconnection Topologies for Floating Photovoltaic System to Enhance the Power Output by Reducing the Mismatch Losses” 14th IEEE PES Asia-Pacific Power and Energy Engineering Conference 2022 (APPEEC) 20 - 23 November 2022 Melbourne, Australia [Paper Accepted for presentation]
[P3]	A.Andreotti, A. D. Pasquale, M. Pagano, N. Ravichandran and F. Volpe, "An Optimal Centralized Control Strategy for Regenerative Braking Energy Flow Exchanges in DC Railway Traction Systems," 2022 International Symposium on Power Electronics, Electrical Drives, Automation and Motion (SPEEDAM), 2022, pp. 436-441, doi:10.1109/SPEEDAM53979.2022.9841998

NEXT YEAR'S WORK IN PROGRESS

The flashover number at the individual pole associated with the stroke location for indirect lightning

The system's induced voltage response for indirect lightning validated with the improvement of the Monte-Carlo Assessment.

Introduction of the lossy ground for a more realistic response

Formulation of Optimization Problem for the optimal location of Surge Arrester and implementation in MATLAB/FICO

Assessment of the lightning performance by using Bidirectional Surge arrester between phases for LIOV and LPOV protection (in collaboration with Sapienza University, Rome).

REFERENCES

1. Andreotti, A., Assante, D., Mottola, F. and Verolino, L., 2009. An exact closed-form solution for lightning-induced overvoltages calculations. *IEEE transactions on power delivery*, 24(3), pp.1328-1343.
2. Andreotti, A., Pierno, A., Rakov, V.A. and Verolino, L., 2012. Analytical formulations for lightning-induced voltage calculations. *IEEE transactions on electromagnetic compatibility*, 55(1), pp.109-123.
3. Andreotti, A., Pierno, A. and Rakov, V.A., 2013. An analytical approach to calculation of lightning-induced voltages on overhead lines in case of lossy ground—Part I: Model development. *IEEE transactions on power delivery*, 28(2), pp.1213-1223.
4. Zhang, X.S., Dong, L., Zeng, G.Q., Huang, S.P., Wu, L., Xiong, R., Wang, H. and Dai, Y.X., 2018, November. Optimal Location of Surge Arresters on an Overhead Distribution Network by Using Binary Particle Swarm Optimization. In *2018 Chinese Automation Congress (CAC)* (pp. 1841-1846). IEEE.
5. Cao, J., Du, Y., Ding, Y., Qi, R., Li, B., Chen, M. and Li, Z., 2022. Practical Schemes on Lightning Energy Suppression in Arresters for Transformers on 10 kV Overhead Distribution Lines. *IEEE Transactions on Power Delivery*, 37(5), pp.4272-4281.

THANK YOU