UNIVERSITÀ DEGLI STUDI DI NAPOLI FEDERICO II

DOTTORATO DI RICERCA / PHD PROGRAM IN
INFORMATION TECHNOLOGY AND ELECTRICAL ENGINEERING

Activities and Publications Report

PhD Student: Nagananthini Ravichandran

Student DR number: DR996074

PhD Cycle: XXXVII
PhD Cycle Chairman: Prof. Stefano Russo

PhD program student's start date: 01.11.2021
PhD program student's end date: 31.10.2024

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PhD scholarship funding entity:
Università Federico II

General information

Nagananthini Ravichandran received in year 2018 the Master of Engineering degree in Power Electronics and Drives from the Anna University, Tamil Nadu, India. She attended a curriculum in ING-IND/33 - Electric Power Systems within the PhD program in Information Technology and Electrical Engineering. She received a grant from Università Federico II.

Study activities

Attended Courses

Year	Course Title	Type	Credits	Lecturer	Organization
1st	Matrix Analysis for Signal Processing with MATLAB Examples	Ad hoc course	2	Prof. Antonio De Maio	DIETI,UNINA
1st	Statistical Data Analysis for Science and Engineering	Ad hoc course	4	Prof. Roberto Pietrantuono	DIETI,UNINA
1st	Big Data Architecture and Analysis	Ad hoc course	5	Proff. Giancarlo Sperl	DIETI,UNINA
2nd	Machine Learning for Science and Engineering Research	Ad hoc course	5	Proff. A. Corazza,	DIETI,UNINA
2nd	Sustainable ship for the energy transition of maritime transport .	Ad hoc course	4	Prof. Tommaso Coppola.	DII, UNINA
2nd	Operational Research: Mathematical Modelling, Methods and Software Tools for Optimization Problems	Ad hoc course	4	Prof. Adriano Masone,	DIETI,UNINA
2nd	Wave propagation along transmission lines	External Course	2	Prof. Farhad Rachidi	EMC, EPFL
3rd	Wave Propagation – Electromagnetic compatibility	External Course	2	Prof. Farhad Rachidi	EMC, EPFL

Attended PhD Schools

Year	School title	Location	Credits	Dates	Organization
1st	Lectures on Computational Linguistics 2022	Napoli, Italy	3	08 - 10.06.2022	AILC, DIETI
2nd	2023 Spring School on Transferrable Skills	Napoli, Italy	2	24 - 25.05.2023	DOP, UNINA

Attended Seminars

Year	Seminar Title	Credits	Lecturer	Lecturer affiliation	Organization
1st	Global And Cluster Synchronization in Complex Networks and Beyond.	0.3	Prof. Mattia Frasca	Università di Catania	SSM
1st	Dissecting glioblastoma by single cell RNA-seq.	0.2	Prof. Itay Tirosh	Weizmann Institute of Science	UNINA
1st	Potential and challenges of next generation railway signaling systems: Moving Block and Virtual Coupling.	0.2	Prof. Valeria Vittorini	University of Naples Federico II, Naples Italy	Consorzio Interuniversitario Nazionale Per L'Informatica (CINI)
1st	Ethics and Politics of AI.	0.3	Prof. Mark Coekelbergh	University of Vienna	Laboratorio Nazionale CINI-ITeM Carlo Savy Complesso Universitario di Monte Sant'Angelo,
1st	Explainable Natural Language Inference. An Introduction to Deep Learning for Natural Language Processing .	0.5	Dr. Marco Valentino	University of Manchester, Manchester, United Kingdom.	Prof. Francesco Cutugno, DIETI, Unina
1st	Using Delays for Control .	0.4	Prof. Emilia Fridman	Tel Aviv University, Tel Aviv, Israel,	Prof. Stefania Santini - DIETI - Unina
1st	Towards AI-Driven Cancer Precision Medicine.	0.2	Prof. Olivier Elemento	Director, Englander Institute for Precision Medicine	DIETI
1st	On using simple optimization techniques for tuning UAVs.	0.4	Prof. Dariusz Horla	Poznan University of Technology, Poznan, Poland	Fabio Ruggiero, PhD (DIETI, UniNA
1st	Accelerated Deep Learning via Efficient, Compressed and Managed Communication.	0.2	Prof. Marco Canini	King Abdullah University of Science and Technology (KAUST),	Prof. Antonio Pescapè (DIETI, UniNA)

				Thuwal, Saudi Arabia	
1st	Population and medical genomics applications to human traits and diseases.	0.2	Prof. Nicole Soranzo	Head of the Genomics Research Centre at Human Technopole (Milan, IT)	UNINA
1st	Drive Converters as Ultra-fast Chargers In An Industrial Scenario Of Heavy-duty EV Mobility Development.	0.4	Prof. Jerzy Szymanski	University of Technology and Humanities in Radom, Poland	Prof. Renato Rizzo, UNINA
1st	Fixed Wireless Access	1	Ing. Angela Deluga,	University of Naples Federico II, Naples Italy	5G Academy
2nd	Publishing Open Access IEEE Journal Articles under the Care-Crui Agreement in Italy.	0.4	Prof. Nino Grizzuti, Ing. Eszter Lukacs, Ing. Stefano Bianco	University of Naples Federico II, IEEE Client Services Manager and CRUI-CARE and INFN, member of CARE Group	IEEE Technology Centre GmbH
2nd	From Cyber Situational Awareness to Adaptive Cyber Defense: Leveling the Cyber Playing Field.	0.4	Prof. Massimiliano	Albanese George Mason University - USA	Prof. Giancarlo Sperlì, DIETI - Unina
2nd	Quantum Complexity.	0.2	Proff. Alioscia Hamma	University of Naples Federico II, Naples, Italy.	SSM, UNINA
2nd	Data mining the output of quantum simulators - from critical behavior to algorithmic complexity.	0.2	Dr. Marcello Dalmonte	Abdus Salam ICTP Trieste - Research Scientist	QSM Seminar Series, UNINA
2nd	Crash course on Data excellence – Part I.	0.2	Prof. Roberto Maranca	Data Excellence Vice President, Schneider Electric	DIETI, UNINA
2nd	How to Publish Open Access Articles with IEEE under the CARE CRUI Agreement .	0.4	Prof. Nino Grizzuti, Ing. Eszter Lukacs, Ing.Stefano Bianco	University of Naples Federico II, Naples, Italy. IEEE Client Services Manager and CRUI-CARE and INFN, member of CARE	IEEE Technology Centre GmbH

				Group	
2nd	Exploring Advanced Aerial Robotics: A Journey into Cutting-Edge Projects and Neural Control.	0.4		University of Naples Federico II,	Prisma Lab, UNINA
2nd	Marine Energy Technologies.	0.6	Dr.Hady H.Fayek	Heliopolis University, Cairo, Egypt	IEEE PELS
3rd	High frequency electromagnetic field coupling to thin-wire structures with symmetrical geometry .	0.4	Dr. Sergey V. Tkachenko	University Magdeburg, Magdeburg, Germany	IEEE Switzerland Chapter on AP/MTT/EMC and EMC Lab EPFL
3rd	Initiation of Positive Cloud-to-Ground Lightning and its Trigger Effects on Upward Lightning.	0.2	Prof. Shanfeng Yuan	Professor, Institute of Atmospheric Physics, Chinese Academy of Sciences	IEEE Switzerland Chapter on AP/MTT/EMC and EMC Lab EPFL
3rd	IEEE PES Live Online: Introduction of WECC-Approved Standard Library Grid-Forming Inverter Models — REGFM_A1 and REGFM_B1.	0.2	Dr. Wei Du, Pacific	Northwest National Laboratory	IEEE Power and Energy Society
3rd	Introduction to Large Language Models: Evolution and the current state.	0.4	Prof. Tanmoy Chakraborty	IIIT-Delhi, Delhi, India, Infosys Centre for Artificial Intelligence (CAI)	Prof. Giancarlo Sperlì (DIETI, UNINA)
3rd	IEEE PES Live Online: Inverter Based Resources: Utility Insights.	0.2	Prof. Mythili Chaganti,	Manager of Distributed Generation team CenterPoint Energy	IEEE Power and Energy Society
3rd	2nd Invited Talk of the Power Pioneers: Leading Lights – Women in Power Webinar Series (“Battery Industry – Revolution, Challenges	0.2	Dr Rashi Gupta	Trailblazer in the renewable energy and advanced lithium battery sectors	IEEE PES/PELS/IAS Hyderabad Section

	and Opportunities").				
3rd	Resource management and orchestration for mixed-criticality cloud/distributed systems.	0.2	Dr-Ing. Gautam Gala	Post Doctoral Researcher Technical University of Kaiserslautern, Germany	Prof. Marcello Cinque
3rd	The maximal covering location problem with edge downgrades.	0.2	Prof. Marta Baldomero-Naranjo	Universidad de Cádiz	Proff. Claudio Sterle, Maurizio Boccia, Adriano Masone - DIETI - UNINA
3rd	IEEE PES Live Online: IEEE 1427 Standard – Definitions and Criteria.	0.3	Mr. Ma	Electrical Engineer and Technical Expert in the Transmission & Distribution Division of Burns & McDonnell	IEEE Power and Energy Society
3rd	IEEE PES Live Online: Solar Design and Installation Training 101:9 – Testing, Performance Eval, Troubleshooting and Maintenance.	0.2	Shuhui Li	Professor, University of Alabama	IEEE Power and Energy Society
3rd	IEEE PES Live Online: IEEE Power and Energy Technology Assessment and Roadmap.	0.2	Dr. Hong Chen,	Manager, PJM Interconnection	IEEE PES Technical Council, IEEE Technology Roadmaps Committee
3rd	From ACE Technologies to Sustainable, Accessible and Equitable Urban Mobility: An Optimization Journey.	0.4	Prof. Mauro Salazar,	Professor, Eindhoven University of Technology, Eindhoven, Netherlands	Prof.ssa Stefania Santini

Research activities

Nagananthini Ravichandran participated in the research dealing with the power quality issues on power distribution lines that are fundamental and need to be addressed with precise solutions for reliable operation. Voltage sags, transients, permanent and temporary interruptions are the issues, and lightning events are major cause factor for all these issues. Lightning-produced overvoltages (LPOV) from direct lightning on the phase conductors and lightning-induced overvoltages (LIOV)

from indirect lightning events at a distance away from the power lines. Both lightning overvoltages can cause insulation failures with subsequent outages of grids and high replacement costs. Thus, an accurate analytical formulation and numerical modelling of LPOV and LIOV are fundamental. Eventually, an effective lightning protection strategy to improve lightning performance is of equal importance for the uninterrupted operation of the grid.

Protection Devices: The prevention of power outages due to lightning in overhead distribution lines is highly challenging. The overvoltage mitigation measures involve the selection and implementation of suitable protective measures considering their advantages, constraints, and costs. Unlike transmission lines, which can be threatened only by direct lightning, distribution lines must face the effects of both direct and indirect lightning events. In this case, proper analysis of the protection devices is indeed for the better lightning performance. This study is carried out to reviewing recent literature with an overview of the lightning protection methods addressing for the direct and indirect lightning events separately. The analysis carried out on the shield wires (SWs) which include underbuilt shield wires and overhead ground wires and line surge arresters (SAs).

Performance of the line arresters: From the analysis on the protection devices for direct and indirect lightning, it is evident that installing only SW protects the system at a relatively low cost compared to installing only SAs. However, neither the solution of installing only SWs nor that of installing only SAs provided significant protection due to the number of flashovers occurring at ungrounded/unprotected towers/poles. Although costly, combined installation of the SW and SAs has improved protection performance compared to their separate installation.

With these results, the type of arrester suitable to enhance the efficiency and reliability of surge protection systems in power distribution networks is further analysed. The following key observations are made on analysing two different technologies; the externally gapped line arrester (EGLA) and non-gapped line arrester (NGLA). The transfer voltage effect is present with both types of arresters and needs to be taken into account during the flashover rate analysis. In terms of discharged energy, the EGLA outperforms the NGLA, making it a better option. Examining the service life of the SAs using cumulative probability reveals that the transfer voltage effect significantly impacts the failure probability and reduces the arrester's overall service life. The EGLA, experiencing lower energy stress, is found to have a longer service life. Implementing externally gapped-type arresters in practice represents a significant advancement in surge protection technology, offering improved performance and advantages compared to traditional surge arresters. Based on these findings, the externally gapped arrester is selected for further analysis, incorporating additional protection mechanisms to mitigate the transfer voltage effect and optimize its performance.

Flashover Mitigation and Optimization of Line Surge Arrester: The part of study aims to examine the capability and effects of a specific type of arrester based on their locations (if placed at intervals). Evaluation of flashover rates is significantly influenced by the random nature of lightning intensity and location. Traditionally, Monte Carlo simulation is employed to replicate the lightning effect using a log-normal distribution and assess the performance of the distribution line. However, when multiple protection scenarios are involved, conducting Monte Carlo simulations can be time-

consuming. Moreover, in realistic scenarios with a large number of network buses, the complexity becomes even more challenging. To address these issues and reduce computational burdens while maintaining the integrity of the analysis, a multi-criteria methodology is utilized. By utilizing this approach, the authors effectively address the uncertainties related to lightning and provide valuable insights for optimizing the protection of distribution networks. By employing this multi-criteria methodology and leveraging probabilistic approaches, the study offers a practical and efficient way to assess the performance of distribution lines under various protection scenarios, considering the uncertainties associated with lightning events. Since lightning performance depends on the type and the location of the protection devices operated, a proper optimization tool for the optimal location of the SAs is applied. The tool allows positioning the SAs optimally considering the transfer effect to reduce the total installation, operation, and post-lightning maintenance cost sustained for the uninterrupted power supply of the distribution network.

Tutoring and supplementary teaching activities

Credits summary

PhD Year	Courses	Seminars	Research	Tutoring / Supplementary Teaching
1st	14	4.3	42	-
2nd	17	3.8	54	-
3rd	2	3.1	60	-

Research periods in institutions abroad and/or in companies

PhD Year	Institution / Company	Hosting tutor	Period	Activities
2nd	Swiss Federal Institute of Technology (EPFL), Lausanne, Switzerland	Farhad Rachidi-Haeri, Adjunct Professor, Head of the Electromagnetic Compatibility (EMC) Group	11.09.2023 – 31.10.2023	Research on Upward Negative Lightning Characteristics
2nd	Swiss Federal Institute of Technology (EPFL), Lausanne, Switzerland	Farhad Rachidi-Haeri, Adjunct Professor, Head of the Electromagnetic Compatibility (EMC) Group	01.11.2023 – 11.12.2023	Research on Upward Negative Lightning Characteristics – Statistical Analysis and Santis Tower Data Evaluation
3rd	Swiss Federal Institute of Technology (EPFL), Lausanne,	Farhad Rachidi-Haeri, Adjunct Professor, Head of the Electromagnetic	08.01.2024 – 31.03.2024	An EMTP - Compatible Frequency-Dependent Model for Vertical Grounding Rods for Transient Studies.

	Switzerland	Compatibility (EMC) Group		Single-Sensor Machine-Learning-Based Lightning Localization using Lightning-Induced Voltages

PhD Thesis

In the PhD Thesis, Nagananthini Ravichandran discusses on the lightning-induced flashovers power distribution networks – specifically on the mitigation strategies and the optimized solutions. Power outages caused by lightning strikes can lead to severe economic and operational disruptions, especially in regions with high ground flash density. The unpredictability of lightning strikes, combined with their ability to induce overvoltages and flashovers on distribution lines, necessitates advanced protection strategies. These protection strategies typically involve the installation of surge arresters (SA) and shield wires (SW) to mitigate the effects of direct and indirect lightning strikes.

Given the extensive number of towers in a distribution network, installing surge arresters on every pole is not economically feasible. Moreover, optimizing the placement of arresters, while ensuring maximum coverage with minimal resources, is a complex problem due to the stochastic nature of lightning strikes. Existing methodologies, such as the Monte Carlo (MC) method combined with heuristic optimization algorithms like the Genetic Algorithm (GA), require extensive computational effort due to the need to simulate thousands of lightning events for every potential protection configuration.

This thesis proposes a novel methodology to address these challenges by integrating the Taguchi method with decision theory for optimal arrester displacement. The Taguchi method, by reducing the number of required simulations through its use of orthogonal arrays, provides an efficient alternative to the traditional Monte Carlo approach, offering comparable accuracy with significantly reduced computational effort. This approach, combined with decision theory, allows for multi-objective optimization, balancing competing objectives which are crucial in effectively minimizing flashover rates, risk, and cost.

Research products

Research results appear in 6 papers published in international journals and 13 contributions to international conferences.

List of scientific publications

International journal papers

1. Cao, J., Andreotti, A., Du, Y., **Ravichandran, N**. and Ding, Y., **Selection of the Lateral Distance for the Assessment Area in a Monte Carlo Procedure Under Indirect Lightning for Overhead Distribution Lines,** *IEEE Transactions on Electromagnetic Compatibility, 65(3), pp.935-939.*, DOI: 10.1109/TEMC.2023.3257361.

2. Stracqualursi, E., Araneo, R., **Ravichandran, N**., Andreotti, A. and Celozzi, S., 2023. **Modeling of conductor's catenary in power lines: Effects on the surge propagation due to direct and indirect lightning.** *IEEE Transactions on Electromagnetic Compatibility.* DOI: 10.1109/TEMC.2023.3288029.

3. Cao, J., Du, Y., Wang, J., Andreotti, A., Ding, Y., **Ravichandran, N**., Zhang, Y. and Cai, L., 2024. Novel **Probabilistic Lightning Performance Evaluation Considering Multi-objective for Differentiated Protection in a Distribution Network**. *Electric Power Systems Research*, *230*, p.110153. DOI: 10.1016/j.epsr.2024.110153.

4. **Ravichandran, N**., Proto, D. and Andreotti, A., 2024. **Surge arrester optimal placement in distribution networks: A decision theory-based approach.** *Electric Power Systems Research*, *234*, p.110744. DOI: 10.1016/j.epsr.2024.110744.

5. **Ravichandran, N**., Proto, D., Mottola. F and Andreotti, A., 2024. Multi-Objective Optimization for Lightning Protection in Distribution Networks: A Novel Approach Based on Design of Experiments in *IEEE Access* ***[Submitted].***

6. Asadi. M, **Ravichandran. N,** Rajabi. S, Miki. T, Karami. H, Rubinstein, M, Rachidi.F, and Andreotti. A. Single-Sensor Machine-Learning-Based Lightning Localization using Lightning-Induced Voltages ***[Submitted].***

International conference papers

1. **Ravichandran, N**., Andreotti, A., Pagano, M., Di Pasquale, A., Volpe, F. Interconnection Topologies for Floating Photovoltaic System to Enhance the Power Output by Reducing the Mismatch Losses (2022). Asia-Pacific Power and Energy Engineering Conference, APPEEC. Melbourne, Australia. November,2022. DOI: 10.1109/APPEEC53445.2022.10072079.

2. Andreotti, A., Di Pasquale, A., Pagano, M., **Ravichandran, N**., Volpe, F. Analysis of Lightning Transients in 2 × 25 kV 50 Hz Railway Traction System using EMTP (2022) 2022 AEIT International Annual Conference, AEIT 2022. Rome, Italy. October 2022. DOI: 10.23919/AEIT56783.2022.9951858.

3. Andreotti, A., Pasquale, A.D., Pagano, M., **Ravichandran, N**., Volpe, F. An Optimal Centralized Control Strategy for Regenerative Braking Energy Flow Exchanges in DC Railway Traction Systems (2022) 2022. International Symposium on Power Electronics, Electrical Drives, Automation and Motion, SPEEDAM 2022, pp. 436-441. Sorrento, Italy. June, 2022. DOI: 10.1109/SPEEDAM53979.2022.9841998.

4. Andreotti, A., **Ravichandran, N**., D'Orazio, L., Villacci, D., Cerretti, A., Araneo, R. and Stracqualursi, E., Assessment of the indirect lightning performance of a distribution line. In 2023 IEEE International Conference on Environment and Electrical Engineering and 2023 IEEE Industrial and Commercial Power Systems Europe (EEEIC/I&CPS Europe) (pp. 1-6). Rome, Italy. June, 2023.DOI: 10.1109/EEEIC/ICPSEurope57605.2023.10194859

5. D'Orazio, L., Andreotti, A., Frain, J.B., Gentilini, I**., Ravichandran, N**., Greco, A., Di Felice, G., Proto, D. and Spitilli, L., 2023. Analysis of the application of LLPDs on a MV feeder of E-Distribuzione. 27th International Conference on Electricity Distribution (CIRED 2023), 2023 p. 633 – 637. Rome, Italy. June 2023.DOI: 10.1049/icp.2023.0438

6. **Ravichandran, N.,** Andreotti, A., Araneo, R., Cao, J., D'Orazio, L., Du, Y., Proto, D. and Stracqualursi, E., 2023, October. Improvement of the Lightning Performance of Overhead Distribution Lines: Possible Solutions. In 2023 International Symposium on Lightning Protection (XVII SIPDA) (pp. 1-6). IEEE. Suzhou, China. September, 2023. DOI: 10.1109/SIPDA59763.2023.10349161.

7. **Ravichandran, N**., Andreotti, A., Di Pasquale, A., Pagano, M., Proto, D., Stracqualursi, E., Araneo, R., D'Orazio, L. Selection of Viable Distribution Line Surge Arrester for Prospective Optimal Protection (2023) 2023 AEIT International Annual Conference, AEIT 2023. Rome, Italy, October 2023.

8. Asadi. M, **Ravichandran. N,** Rajabi. S, Miki. T, Karami. H, Rubinstein.M, Rachidi.F, and Andreotti.A. Single-Sensor Machine-Learning-Based Lightning Localization using Lightning-Induced Voltages. 37th International Conference on Lightning Protection. Dresden, Germany. September 2024. [**Presented**].

9. Alipio. R , Duarte. N**, Ravichandran. N**, Andreotti. A, and Rachidi. F. An EMTP-Compatible Frequency-Dependent Model for Vertical Grounding Rods for Transient Studies; 37th International Conference on Lightning Protection. Dresden, Germany. September 2024. [**Presented**].

10. Ghimire. B, **Ravichandran. N**, Andreotti. A, Narayan Poudyal. N Khem, Sharma. S, Karki. R, Ground Flash Density Mapping in Nepal: Enhancing Lightning Performance and Resilience of Distribution Lines. Australasian Universities Power Engineering Conference (AUPEC). Sydney, Australia. November 2024. [**Submitted**].

Date 15.10.2024

PhD student signature 

Supervisor signature