Electrical Engineering Postgraduate Program

UNIVERSIDADE FEDERAL DE SÃO JOÃO DEL-REI
PRÓ-REITORIA DE PESQUISA

CENTRO FEDERAL DE EDUCAÇÃO TECNOLÓGICA DE MINAS GERAIS
DIRETORIA DE PESQUISA E PÓS-GRADUAÇÃO

Unit Plan

DISCIPLINE: Lightning Induced Voltages on Distribution Systems	**CODE**: EL0050
PROFESSOR: Daniele Mestriner and Marco Aurélio de Oliveira Schroeder	

Validade: 1st Semester 2024.
Carga Horária: 60 h
Credits: 4
Concentration Area: Power Systems

Course Overview

The course will analyse the damages that can occur con distribution systems due to lightning; in particular, the focus will be on the faults related to lightning striking in the neighbour of the line location. The lessons will be focused on the description of the lightning phenomena, on the computation of the generated lightning electromagnetic fields and on the interaction of lightning events with distribution systems.

Course requirements (assessment, activities, etc.)

The main requirements for a complete understanding of the course are :

1) Complete knowledge of Electrical Circuits
2) Good knowledge of Electromagnetism.
3) Basic knowledge of Matlab-Simulink
4) Good knowledge of English language

Learning Objetives

The objectives of the course are:

1) To make the students aware of the lightning-induced voltages issue.
2) To provide the students a theoretical base for the analysis of lightning-induced voltages phenomenon.
3) To provide the students a practical instrument for analysing the possible damages occurring on a distribution system.

Course Calendar

1. Introduction to lightning discharge (6 hours)

- Description of the phenomenon

Unit Plan

- Main Parameters
- The lightning modelling
  i. Engineering models
  ii. Antenna models
  iii. Distributed Circuit models
  iv. Phsyical models
- Engineering models: The transmission line-type and Travelling-Current Source
  i. The channel-base current
  ii. The attenuation function
- Matlab application

2. The lightning Electromagnetic fields (6 hours)

- Theoretical description
- Evaluation with Perfect Electric Conductor ground
- Evaluation with finite soil conductivity considering frequency dependent parameters: the exact approach and the Cooray-Rubinstein approximation
- Numerical assessment and techiniques for reducing the computational effort
- Particular cases: the shielding effect of buildings
- Matlab application

3. The Lightning-induced voltages (6 hours)

- Issues related to lightning on distribution lines
- Theoretical description of Agrawal's model
- Numerical implementation of Agrawal's model in a FDTD code
- Lightning performance
- Matlab application: Lightning performance with Rusck.

4. The LIGHT-PESTO Code (12 hours)

- Introduction to the software
- Examples
- Exercises

Methodology and resources

Unit Plan

The course will be focused on two parts: theoretical and practical.

At the end of each theoretical part, there will be dedicated hours for the exercises to be performed in Matlab-Simulink.

After that, the student will have to solve by himself/herself a practical problem provided by the learner.

Frequency Control

75% participation in online classes

Assessment Criteria

A1 - Four problems (one for each section) will be provided to the student, which has to solve it and provide it to the learner at the end of the course.

A2 - Moreover, the student should have understood the basic principles of lightning modelling from a theoretical point of view and should be able to evaluate the breakdown of insulators through the LIGHT-PESTO code.

Final grade: (A1 + A2)/10

Basic Bibliography

1. Sadiku, M. N., & Alexander, C. K. (2007). Fundamentals of electric circuits. McGraw-Hill Higher Education.

2. Paul, C. R. (2007). Analysis of multiconductor transmission lines. John Wiley & Sons.

Additional Bibliography

3. Cooray, G. V. (2003). The lightning flash (No. 34). Iet.

4. M. Brignone, F. Delfino, R. Procopio, M. Rossi and F. Rachidi, "Evaluation of Power System Lightning Performance, Part I: Model and Numerical Solution Using the PSCAD-EMTDC Platform," in *IEEE Transactions on Electromagnetic Compatibility*, vol. 59, no. 1, pp. 137-145, Feb. 2017, doi:

10.1109/TEMC.2016.2601640.

5. M. Brignone, F. Delfino, R. Procopio, M. Rossi and F. Rachidi, "Evaluation of Power System Lightning Performance—Part II: Application to an Overhead Distribution Network," in *IEEE Transactions on Electromagnetic Compatibility*, vol. 59, no. 1, pp. 146-153, Feb. 2017, doi: 10.1109/TEMC.2016.2601657.

6. D. Mestriner, M. Brignone, R. Procopio, A. Piantini and F. Rachidi, "A New Channel-Base Lightning Current Formula With Analytically Adjustable Parameters," in *IEEE Transactions on Electromagnetic Compatibility*, vol. 63, no. 2, pp. 542-549, April 2021, doi: 10.1109/TEMC.2020.3009273.

7. L. Farina, D. Mestriner, R. Procopio, M. Brignone and F. Delfino, "The Lightning Power Electromagnetic Simulator for Transient Overvoltages (LIGHT-PESTO) Code: A User-Friendly Interface With the MATLAB-Simulink Environment," in *IEEE Letters on Electromagnetic Compatibility Practice and Applications*, vol. 2, no. 4, pp. 119-123, Dec. 2020, doi: 10.1109/LEMCPA.2020.3032180.

8. M. Brignone, D. Mestriner, R. Procopio, A. Piantini and F. Rachidi, "On the Stability of FDTD-Based Numerical Codes to Evaluate Lightning-Induced Overvoltages in Overhead Transmission Lines," in *IEEE Transactions on Electromagnetic Compatibility*, vol. 62, no. 1, pp. 108-115, Feb. 2020, doi: 10.1109/TEMC.2018.2890043.

ASSINATURAS

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