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Lightning return stroke electromagnetics - time domain evaluation and application

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Abstract

The work presented extends and contributes to the research of modelling lightning return stroke (RS) electromagnetic (EM) fields in the time domain. Although previous work in this area has focused on individual lightning electromagnetic pulse (LEMP) modelling techniques, there has not been an investigation into the strengths and weaknesses of different methods, as well as the implementation considerations of the models. This work critically compares three unique techniques (Finite Antenna, FDTD, and Single Cell FDTD) under the same ideal simulation parameters. The research presented will evaluate the EM fields in the range of 50 m to 500 m from the lightning channel. This range, often referred to as the near field distance, has a significant effect on lightning induced overvoltages on distribution lines, which are primarily created by the horizontal EM fields of the RS channel. These close distances have a significant effect on the model implementations, especially with the FDTD method. Each of these modelling methods is explained and tested through examples. The models are implemented in C++ and have been included in the Appendix to aid in future implementation. From the model simulations it is clear that the FDTD method is the most comprehensive model available. It allows for non-ideal ground planes, as well as complex simulation environments. However, FDTD has a number of numerical related errors that the Finite Antenna method does not suffer from. The Single Cell FDTD method is simple to implement and does not suffer from the same numerical errors as a full FDTD implementation, but is limited to simple simulation environments. This work contributes to the research field by comparing and evaluating three techniques and giving consideration to the implementation and the applicability to lightning EM simulations.