Evaluation of the statistical distributions of transient impedance of the horizontal grounding electrode subject to lightning strike

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In the framework of the lightning protection systems (LPS), transient impedance is considered as a key parameter to determine the performance of a given system [1]. It is well documented that such complex systems require a careful analysis due to the severity and risk of under-estimating protection levels along with the volatility of the inputs range. On the one hand, different strategies have been successfully tested during the past years, mainly based on different assumptions and methods of solution, e.g. see use of a direct time domain solution for the transient impedance (ZT) [2]. On the other hand, the uncertainty quantification (UQ) is needed for the assessment of ZT statistics. Sesnic et al. [3] proposed an accurate assessment of LPS sensitivity analysis at sparing computing costs. Indeed, due to the inability to precisely measure certain input parameters (soil conductivity, for instance) or in relation with the stochastic nature of the phenomena (e.g. lighting pulse) [1], it is major concern to evaluate ZT distribution for a realistic computational cost. In this proposal, a perfectly conducting (PEC) grounding electrode is excited by a lightning strike with uncertain inputs as given in Tab. 1. This work lays emphasis on the use of three stochastic strategies, including classical Monte Carlo (MC) method, stochastic collocation technique (SCT), and stochastic reduced order method (SROM) [4]. Fig.1 shows the capability of SCT and SROM to reproduce ZT statistical distributions at early stage and/or during steady state, comparatively to MC. The final paper will give details of the theoretical background of the proposed stochastic methods and their validation through numerical test cases.

Table 1. Distributions of variable parameters

Parameter	Relative soil permittivity	Depth of the electrode [m]	Lightning pulse front time [µs]	Lightning pulse time-to-half [µs]	Electrode length [m]	Soil conductivity [mS/m]
Distribution range	5 – 15	0.2 – 0.8	0.4 – 4	50 – 70	4 – 6	0.05 – 0.15

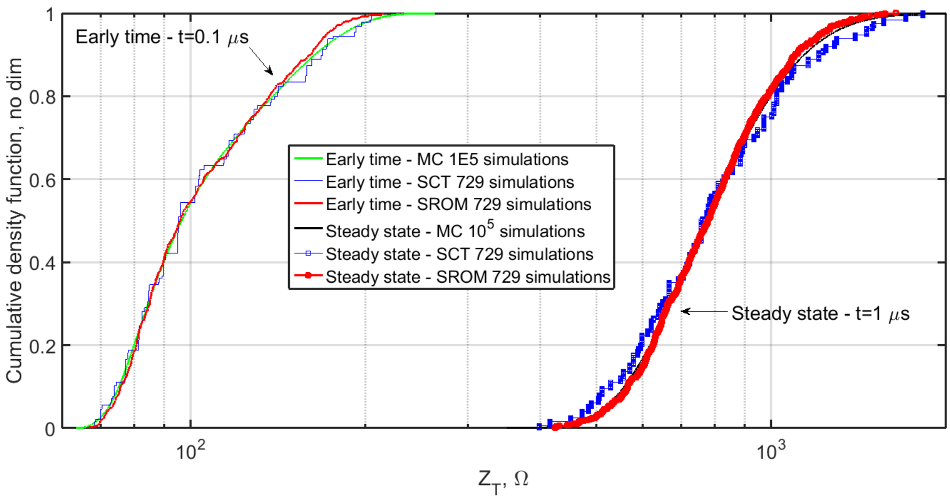

Figure 1. Cumulative density function (CDF) of ZT at time t1=0.1us (early time) and t2=1us (steady state).

References

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