Electromagnetic Simulation Based on Drift and Diffusion Currents for Real-Time Systems

Authors : Alexander Norbach

Abstract : The script in this paper describes the use of advanced simulation environment using electronic systems (Microcontroller, Operational Amplifiers, and FPGA). The simulation may be used for all dynamic systems with the diffusion and the ionisation behaviour also. By additionally required observer structure, the system works with parallel real-time simulation based on diffusion model and the state-space representation for other dynamics. The proposed deposited model may be used for electrodynamic effects, including ionising effects and eddy current distribution also. With the script and proposed method, it is possible to calculate the spatial distribution of the electromagnetic fields in real-time. For further purpose, the spatial temperature distribution may be used also. With upon system, the uncertainties, unknown initial states and disturbances may be determined. This provides the estimation of the more precise system states for the required system, and additionally, the estimation of the ionising disturbances that occur due to radiation effects. The results have shown that a system can be also developed and adopted specifically for space systems with the real-time calculation of the radiation effects only. Electronic systems can take damage caused by impacts with charged particle flux in space or radiation environment. In order to be able to react to these processes, it must be calculated within a shorter time that ionising radiation and dose is present. All available sensors shall be used to observe the spatial distributions. By measured value of size and known location of the sensors, the entire distribution can be calculated retroactively or more accurately. With the formation, the type of ionisation and the direct effect to the systems and thus possible prevent processes can be activated up to the shutdown. The results show possibilities to perform more qualitative and faster simulations independent of kind of systems space-systems and radiation environment also. The paper gives additionally an overview of the diffusion effects and their mechanisms. For the modelling and derivation of equations, the extended current equation is used. The size K represents the proposed charge density drifting vector. The extended diffusion equation was derived and shows the quantising character and has similar law like the Klein-Gordon equation. These kinds of PDE's (Partial Differential Equations) are analytically solvable by giving initial distribution conditions (Cauchy problem) and boundary conditions (Dirichlet boundary condition). For a simpler structure, a transfer function for B- and E- fields was analytically calculated. With known discretised responses $g_1(k \cdot Ts)$ and $g_2(k \cdot Ts)$, the electric current or voltage may be calculated using a convolution; g_1 is the direct function and g_2 is a recursive function. The analytical results are good enough for calculation of fields with diffusion effects. Within the scope of this work, a proposed model of the consideration of the electromagnetic diffusion effects of arbitrary current 'waveforms' has been developed. The advantage of the proposed calculation of diffusion is the real-time capability, which is not really possible with the FEM programs available today. It makes sense in the further course of research to use these methods and to investigate them thoroughly.

Keywords : advanced observer, electrodynamics, systems, diffusion, partial differential equations, solver
Conference Title : ICCEEFSM 2020 : International Conference on Computational Electromagnetics, Electrodynamics and Field-Solving Methods
Conference Location : Rome, Italy
Conference Dates : January 16-17, 2020