Stable time domain analysis of interconnection systems excited by wideband pulses

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Time domain methods for transient analysis of pulse excited interconnection structures are of high interest, since frequency domain methods with IFT applied to UWB pulses need much computation time. A further advantage of time domain methods is the opportunity for including non-linearities. Unfortunately, numerical time domain methods sometimes show the problem of late time instability.
The PEEC method is a wide spread numerical method for obtaining frequency and time domain numerical solutions of EFIE. The possible instability of time domain solutions is well known and can complicate or even make impossible the use of the PEEC method.
A time domain model based on the full-wave PEEC method is represented by a linear circuit containing controlled voltage and current sources with delay. Such circuits are described by a system of linear delay differential equations (LDDE). The stability analysis of differential equation (DE) systems which are to be solved numerically has to take into account two basic aspects. One is the instability of the solution caused by the numerical integration rule or an inadequate time step of integration. The other one is that the DE system may have a divergent solution independent on the numerical method used. Both possibilities have been investigated. Recent papers show that the instability is caused by not exact correspondence of the behavior of LDDE as a mathematical model after discretization of the interconnection structure described by MPIE as original mathematical model [1]. It has been recognized that in standard PEEC the instability is caused by introduction of ideal time delay sources.
More precise modeling EFIE by using relatively simple macromodels instead of ideal time delay sources has been proposed in [1]. In frequency domain such macromodels have transfer functions with a magnitude that tends to zero for increasing frequencies. In contrast, ideal delay functions have no damping with the frequency what the model makes unphysicaly and, as consequence, unstable. The main disadvantage of this approach is the introduction of additional variables corresponding to additional circuit elements and, consequently, an essential increasing the simulation time.
A novel effective method for modeling the frequency responses of integrals of the Green's function in time domain has been developed. Such an approach is based on the recursive convolution technique. It has been presented an original method for computation the instantaneous values of controlled sources with delay and damping. The new solution is very suitable for incorporation in a SPICE-like time domain circuit simulator. The model has been tested and shows a good performance and a stable solution as well.

[1] S. V. Kochetov, G. Wollenberg, *Stability of full-wave PEEC models: reason for instabilities and approach for correction*. IEEE Trans. on EMC, accepted.