Multidimensional Techniques for Simulating Frequency Modulated Signals

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In radio frequency applications, electric circuits produce carrier waves, whose amplitude and frequency may change due to slowly varying signals. Hence simulating a mathematical model based on differential algebraic equations (DAEs) becomes inefficient, since fast oscillations restrict the size of time steps in a numerical integration. Alternatively, a multidimensional representation allows to decouple the widely separated time scales in the arising signals. Consequently, the system of DAEs is transformed into a system of partial differential algebraic equations (PDAEs). The determination of an adequate local frequency function is crucial for the efficiency of this multidimensional model. Inappropriate choices cause unrequested oscillations in the multivariate representation. We construct a minimisation criterion to obtain a corresponding solution, which exhibits a minimal amount of such oscillations. Solutions of the system of PDAEs are interconnected by a transformation formula. Employing this structure, a variational calculus yields an additional condition, which an optimal solution has to satisfy. We apply this constraint in an according numerical method to determine a suitable representation. Test results demonstrate that the PDAE model including the optimisation technique enables an efficient simulation of frequency modulated signals.

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