Chapter 9: On the Fractional-Order Circuit Design: Sensitivity and Yield

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The engineering system design process requires a multitude of system simulations to obtain the optimal system parameters needed to achieve predefined design specifications. Using fractional calculus in system design opens a new era by offering extra degrees of freedom that enhance the design searching region, hence improving the system performance. Applying the optimization techniques using those extra degrees of freedom yields a substantial step toward a better optimum performance. An adjoint system technique for deriving the sensitivities based on partial derivatives, even for fractional powers, is presented. It allows the use of the efficient gradient optimization techniques to achieve a minimax optimum. In general, a minimax optimum is not the best nominal design that results in high yield in the presence of circuit parameter tolerances. A novel optimization approach that deals with yield optimization is presented. The approach is based on a multivariate Padé approximating model exploiting fractional-order elements. The proposed model utilizes trust region methodology to avoid the slow convergence of linear models and acquire the features of quadratic models. A discussion of sensitivity analysis in the frequency domain of fractional-order elements using the adjoint matrix approach is presented. Sensitivity and yield optimization approaches are validated by finding the optimal designs for some filter examples..