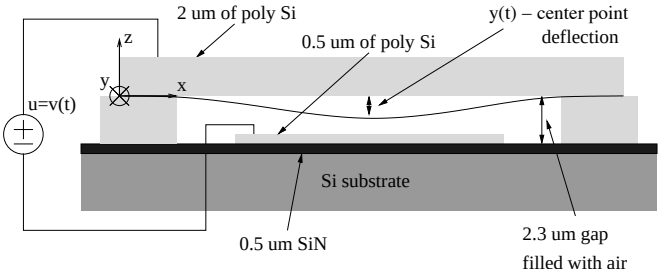
A Piecewise-linear Moment-matching Approach to Parameterized Model Order Reduction for Highly Nonlinear Systems

B. Bond, L. Daniel
Sponsorship: SRC/FCRP GSRC, NSF, DARPA

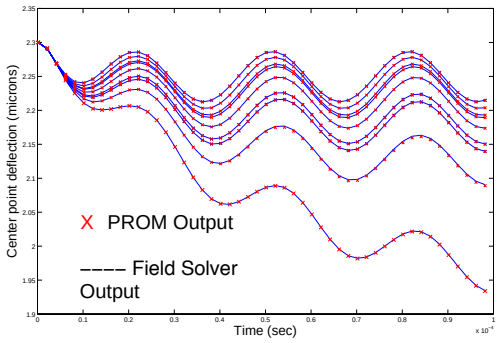
The automatic extraction of parameterized macromodels for modern mixed signal System-on-Chips is an extremely challenging task due to the presence of several nonlinear analog circuits and Micro-Electro-Mechanical (MEM) components. The ability to generate Parameterized Reduced Order Models (PROM) of nonlinear dynamical systems could serve as a first step toward the automatic and accurate characterization of geometrically complex components and sub-circuits, eventually enabling their synthesis and optimization.

Our approach to this problem combines elements of a non-parameterized trajectory piecewise linear method [1] for nonlinear systems with a moment matching parameterized technique [2] for linear systems. By building on these two existing methods, we have created an algorithm for generating PROMs for nonlinear systems. The algorithms were tested on three different systems: a MEM switch, shown in Figure 1, and two nonlinear analog circuits. All of the examples contain distributed strong nonlinearities and possess some dependence on several geometric parameters.

In addition, we have proposed a model-construction procedure in which we approximate the system sensitivity to parameters of interest for the purpose of efficiently sampling important regions of the parameter space. Figure 2 shows the output of one PROM created for the example in Figure 1 and compared to the field solver output of the full nonlinear system at several parameter values. Typical PROMs constructed in this manner can be accurately reduced in size by a factor of 10, yielding a speedup of a factor of 10 in general. For further details on parameter-space accuracy and cost of the algorithms, see [3].



▲ Figure 1: Application example: MEM switch realized by a polysilicon beam fixed at both ends and suspended over a semiconducting pad and substrate expansion



▲ Figure 2: Center point deflection predicted by our parameterized reduced model (crosses) at a series of parameter values, compared to a finite difference detailed simulation (solid lines).

REFERENCES

[1] M. Rewienski and J.K. White, "A trajectory piecewise-linear approach to model order reduction and fast simulation of nonlinear circuits and micromachined devices," in *Proc. IEEE/ACM International Conference on Computer Aided-Design,* San Jose, CA, Nov. 2001, pp. 252-257.

[2] L.Daniel, C.S. Ong, S.C. Low, K.H. Lee, and J.K. White, "A multi-parameter moment-matching model reduction approach for generating geometrically parameterized interconnect performance models," *IEEE Trans. on Computer-Aided Design of Integrated Circuits and Systems*, vol. 23, no. 5, pp. 678-693, May 2004.

[3] B. Bond and L. Daniel, "Parameterized model order reduction of nonlinear dynamical systems," in *Proc. IEEE Conference on Computer-Aided Design*, San Jose, CA, Nov. 2005, pp. 487-494.