MEMS+® 6.0 for MEMS Device Design

Explore Concepts | **Optimize Designs** | **Predict Yield**

The Challenge

MEMS development takes too long…

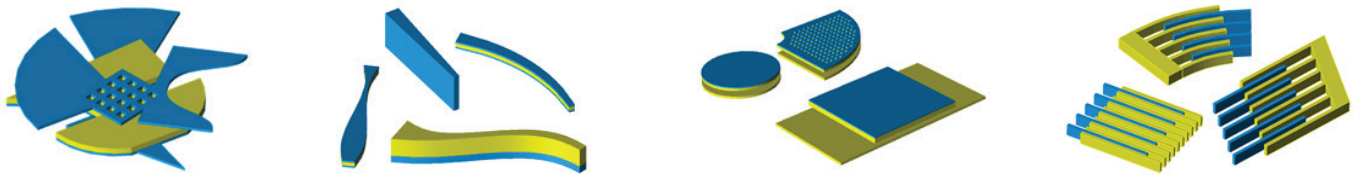
- Conventional FEA (finite element analysis) is time consuming, even for assessing basic behavior…
- Full multi-physics coupling is approximated or ignored (this can make or break devices)
- Transient simulations are often infeasible because they take too long
- Yield studies are not performed
- Numerous, time consuming in-fab learning cycles are used in place of simulation
- Market windows are missed!

The Solution

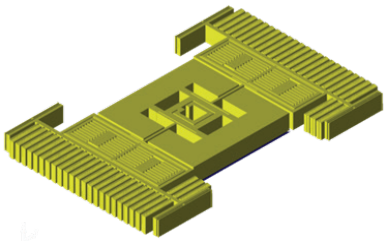
Reduce development time using ***MEMS+*** models

- Assemble models from a library of MEMS-specific, high-order, parametric finite elements
- ***MEMS+*** models are compact (10s to 1,000s unknowns) and simulate really fast (> 100X faster than FEA)
- The same model runs in multiple simulators: ***MEMS+***, MATLAB, Simulink, and Cadence Virtuoso
- Fully coupled multi physics: mechanics, electrostatics, piezo, thermal, gas damping, packaging and more…
- Non-linear effects included: mechanical and electrostatic; pull-in, lift-off, spring softening; quadrature, frequency hysteresis, …

MEMS+ Component Library: MEMS-specific, 3D, high-order, parametric finite elements



Everything needed to assemble multi-physics models of complex, real-world sensor and actuator designs



Intuitive, process-aware, 3D interface for assembling parametric models

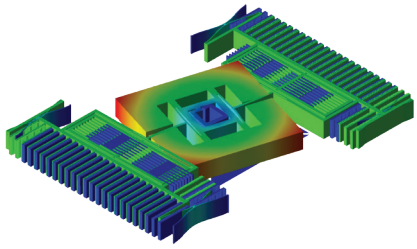
MEMS+ Simulator

MathWorks MATLAB/Simulink

cadence Virtuoso

Exported ROM for Verilog-A and Simulink

Complete analysis options: DC, modal, AC, and transient, pull-in/lift-off, frequency hysteresis



3D animation and X-Y graphing from all simulators

The simulation speed of MEMS+ models opens exciting new possibilities for concept exploration, design optimization and yield analysis

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MEMS+® 6.0 for MEMS+IC Co-Design

Closed Loop | **Corner Cases** | **Noise Analysis**

The Challenge

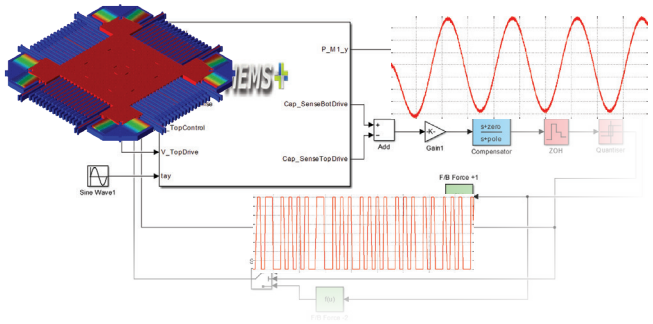
Months are wasted on hand-crafting different MEMS device models for system and IC designers.

- Different models for different users…
  - System designers use MATLAB/Simulink
  - IC designers use SPICE or Verilog-A
  - MEMS designers use FEA
- Hand-crafted MEMS models for Simulink, SPICE, or Verilog-A are common practice. These are…
  - Inaccurate due to over-simplification: Degrees of freedom and non-linear effects are neglected
  - Not parametric with respect to design or environment variables
  - Prone to human error and rapidly go out of sync between design groups

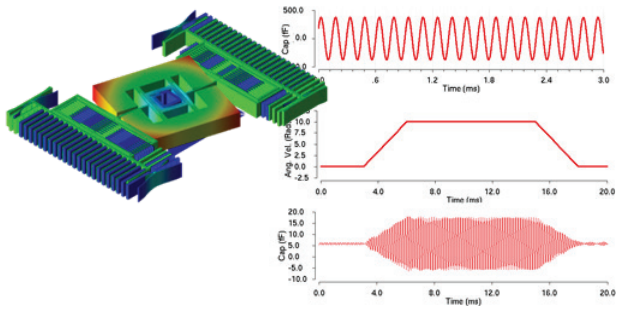
The Solution

Use ***MEMS+*** to generate one model for everyone.
Save months and avoid design errors.

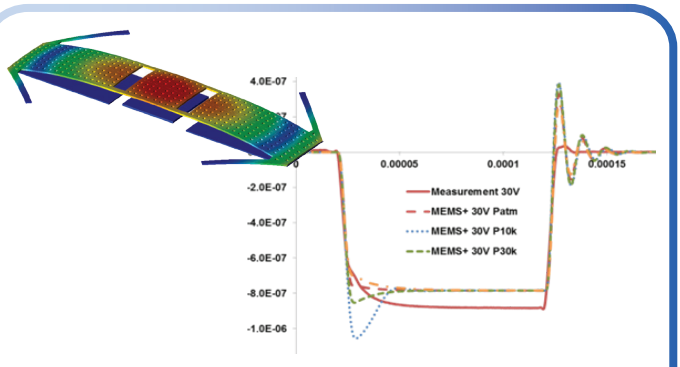
- A single ***MEMS+*** model is the source for all formats: MATLAB, Simulink and Verilog-A
  - Redundant modeling effort is eliminated
- Generated ROMs are tunable for accuracy versus simulation speed
  - Selectively include mechanical degrees of freedom and non-linear effects
  - Selectively expose design and environment variables in system and circuit symbols
- A source of human error is removed and it's easier for design teams to stay in sync



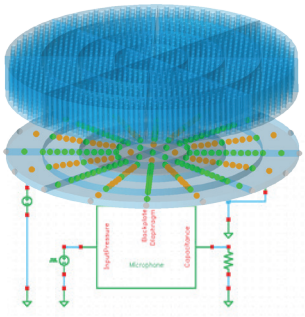
Closed-loop simulation in Simulink and Verilog-A compatible simulators



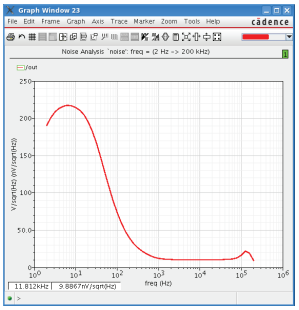
Gyro transient simulated in minutes



Transient simulation of a Bi-CMOS RF switch closing and opening



MEMS+ microphone model includes mechanics, electrostatics and fluidics (air) effects



Noise analysis in Cadence Virtuoso

MEMS+ takes MEMS+IC co-design to a whole new level!

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