Behaviorsal design and simulation environment using parameterized libraries

A realistic MEMS simulation requires that 3-D representations of multi-physics devices be created and boundary conditions applied such that the devices can be evaluated in multiple degrees of freedom. The complexity of the modeling and the computation of the equations used to represent the models demand a streamlined approach that enables the design procedure to be both fast and accurate. Coventor’s ARCHITECT is a new MEMS paradigm that uses a three-step approach for accurate high-level design and simulation:

- **Capture** a design in circuit form using libraries of parametric elements. The capture process uses placement and interconnect techniques familiar to digital designers.
- **Simulate** device behavior using SPICE-like simulation for mixed-domain technologies. The result is an accurate and rapid solution available in tabular and graphical formats.
- **Optimize** design using advanced techniques such as sensitivity and Monte Carlo analyses. Hundreds of design iterations can be evaluated quickly to produce a device that minimizes the influences of manufacturing tolerances.

Schematic of complete RF switch including complete meander suspensions, all perforated plates and drive electrodes.


**ARCHITECT** includes:

- Graphical schematic capture engine
- Mixed-signal circuit simulator
- Graphical timing and waveform editor
- Schematic driven layout generators: create GDS II from circuit schematic
- Library of standard mechanical and electrical components plus choice of one parameterized MEMS library with template customization

**Optional add-ons:**

- Manufacturing analysis software for tolerance performance
- DESIGNER 3-D model creation tool that accepts layout generator output
- Additional multi-physics libraries in the electromechanical, electromagnetic, optical, or fluidics domains
**Capture**

The graphic schematic capture engine uses symbols and customizable parameter tables from electromechanical, electromagnetic, optical, and fluidic library elements. User-defined material property and process parameter values update the parametric libraries automatically. Each electromechanical parameterized model is accurate in 6 degrees of translational and rotational freedom, and up to 5 electrical degrees of freedom. All models allow extensive customization for changes in geometry and overrides of process parameters. In addition, new fixed custom macromodel elements can be extracted from detailed FEM/BEM simulations and added to the libraries. The finalized schematic is netlisted to create the interconnect file needed for simulation.

**Simulate**

The mixed technology, mixed-signal circuit simulator simulates the reduced-order parametric models. The fast DC and AC results can be displayed in graphical format (charts, histograms, scatter plots) using a timing and waveform editor. Multiple signals may be displayed or overlaid for comparison, with many display adjustments. Probing capability allows a signal to be displayed at any interconnect point in the original captured schematic.

**Optimize**

A complete add-on manufacturing analysis module allows for parametric, statistical, and stress analysis. Sensitivity analysis assesses critical operating characteristics by varying individual parameters in batch run simulations. Monte Carlo 3 sigma statistical simulation optimizes manufacturability by evaluating component tolerances. The user also can evaluate stresses on components by altering specified operating conditions and assessing results.

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**Coventor products**

CoventorWare is ideal for developing MEMS and microsystems for an unlimited variety of applications including optical communications, RF/wireless communications, biotechnology, automotive, and sensors.

- **ARCHITECT**: Multi-domain technology simulator for device, component or system level products including physical models, control models and electronics
- **DESIGNER**: MEMS device construction tool; generates 2-D mask layouts and 3-D solid models; includes material property database, process editor and import/export capabilities
- **ANALYZER**: Group of field solvers for detailed physical analysis requiring thermoelectromechanics, optics, fluidics, electromagnetics, and more
- **INTEGRATOR**: Tools to extract detailed design-specific behavioral models from Finite Element straight into Saber, Cadence or Matlab-Simulink
- **MEMulator**: A versatile virtual prototyping tool used to emulate complex MEMS processes
- **Etch3D**: A 3D simulator for anisotropically etching Silicon in any orientation with etchants such as KOH, TMAH, and others

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