A Perturbation Method for the 3D Finite Element Modeling of Electrostatically Driven MEMS

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Modeling electrostatically driven MEMS

- Lumped spring-mass models
  - helpful for physical insight
  - neglect important effects such as bending of plates and the fringing field effects
- Finite element (FE) method
  - adapted for complex geometries
  - compute accurately the fringing field effects at the expense of dense discretization near corners
  - movement modeling usually requires successive meshing and computations for each new position
  - classical approach computationally expensive
- Perturbation method
  - unperturbed field computed in a global domain without the presence of some conductive regions
  - no mesh of perturbing domains
  - possible symmetries or analytical solution
  - applied source to the perturbation problems
  - perturbed field determined in a local domain
  - subproblem-adapted meshes
- Iterative sequence of perturbation problems
  - when coupling between sub-regions is significant
  - successive perturbations in each region are computed from one region to the other
  - each sub-problem gives a correction as a perturbation

Perturbation method

- Unperturbed domain: parallel-plate capacitor
- Perturbing domain: micro-beam (100µm × 10µm)

Unperturbed problem

- Unperturbed electric scalar potential FE formulation
  \(-\varepsilon \nabla v \cdot \nabla v^p\) _Ω_p = 0

Mesh of the unperturbed domain

\(\nabla v^p\) is projected on \(\partial \Omega_p\)

Application

Conclusions

- A perturbation approach based on electric scalar potential FE formulation has been presented
  - adapted for complex geometries
  - unperturbed field computed in a global domain without the presence of conductive regions
  - unperturbed field applied as source in \(\Omega_p\)
  - perturbed field determined in reduced domain \(\Omega_p\)
  - iterative procedure used when the coupling between the sub-regions is significant

- Convergence acceleration of iterative sequence in progress

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