Lecture 22: Comb Drive & Equivalent Circuits II

- **Announcements:**
  - Module 13 on Equivalent Circuits II online
  - HW#6 online soon
  - Project slide #2 due Friday, April 15

- **Reading:** Senturia, Chpt. 5, Chpt. 6
- **Lecture Topics:**
  - Energy Conserving Transducers
    - Charge Control
    - Voltage Control
  - Parallel-Plate Capacitive Transducers
    - Linearizing Capacitive Actuators
    - Electrical Stiffness
  - Electrostatic Comb-Drive
    - 1st Order Analysis
    - 2nd Order Analysis

- **Reading:** Senturia, Chpt. 6, Chpt. 14
- **Lecture Topics:**
  - Input Modeling
    - Input Equivalent Ckt.
  - Current Modeling
    - Output Current Into Ground
    - Input Current
    - Complete Electrical-Port Equiv. Ckt.
  - Impedance & Transfer Functions

- **Last Time:** Going through Module 12 slides 26-35

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**Input Electrical Equivalent Ckt.**

For now, address the motional behavior, not the parasitic...
In phasor form:
\[ I_2(jw) = -jw \cdot \frac{\partial C_2}{\partial x} \cdot x \]

By motional current:
\[ I_2(jw) = -jw V_p \frac{\partial C_2}{\partial x} \cdot x \]

Describing Matrix:
\[
\begin{bmatrix}
    e_2 \\
    f_2
\end{bmatrix} =
\begin{bmatrix}
    \eta & 0 \\
    0 & -1/\eta
\end{bmatrix}
\begin{bmatrix}
    e_1 \\
    f_1
\end{bmatrix}
\]
\[ I_i(j\omega) = \frac{j\omega C_1 V_i + j\omega C_1 \frac{\partial C_1}{\partial x} x - j\omega V_p \frac{\partial C_1}{\partial x} x}{\kappa} \]

Due to mass motion

Feedthrough Current

Motional Current