Automated Passband Tuning of High-Order Microelectromechanical Filters

Henry G. Barrow
Clark T.-C. Nguyen, BPN707

Objective: Develop electrostatic tuning techniques to provide complete corrective control over high-order filter passbands.

Approach: harness the voltage-controlled tuning capability of high-Q capacitive-gap transduced MEMS resonators to realize bandpass filters with sharp rolloffs and a resiliency to fabrication mismatch.

Importance of Q

Insertion loss increases as resonator Q decreases. This effect is compounded as filter order increases.

Importance of Tuning

- Narrowband filters are extremely sensitive to resonator frequency mismatch.
- MEMS resonators can have up to 10,000ppm mismatch, even with DUV lithography.

Electrical Stiffness Tuning

The enhanced electric field generates an attractive force in the direction of motion that counteracts the mechanical stiffness.

- This force is proportional to displacement, which effectively makes it an electrical stiffness ($k_e$).

Filter Tuning Protocol

1. Measure the frequency characteristic without any corrective tuning.
2. Adjust a single resonator's tuning voltage $V_{t, i}$ while measuring the filter's frequency characteristic.
3. Set $V_{t, i}$ to maximize the (integrated) area under the frequency characteristic.
4. Repeat steps 2 and 3 for each tuning voltage on each resonator and iterate the entire process as needed.

- This procedure utilizes a purely mathematical optimization ► automation is easily programmable.
- This protocol applies to all tunable resonator filters, including those comprised of high-frequency disks.