Introduction:

- Electromechanical vibrating energy harvesting using electrostrictive material
- Viscoelastic polymer cantilevers: Large strain, Low quality factor
- Electrostrictive polymer layer: Large sensitivity strain, High permittivity

Use of COMSOL multiphysics:

- Beam: L = 600 µm, b = 300 µm and e = 10 µm
- SU-8: ρ = 960 kg/m³, E = 3 GPa.

Two actuation methods:

1. Harmonic actuation force (support fixed) ➔ Viscoelastic losses
2. Harmonic vertical acceleration ➔ Support losses + viscoelastic losses

Analytical model of quality factors:

The total quality factor: 
\[ Q_{\text{tot}} = \frac{1}{2} \left( 1 - \left( \frac{f_r}{f_0} \right)^2 \right)^2 \]

1. \( f_r \) is the resonance frequency
2. \( f_0 \) is the undamped natural frequency

Viscoelastic losses ➔ 
\[ Q_{\text{viscoel}} = \frac{E'}{E''} \]

Support losses ➔ 
\[ Q_{\text{supp}} = \frac{1}{Q_{\text{tot}}} - \frac{1}{Q_{\text{viscoel}}} \]

Results and Discussions:

- Harmonic actuation force: \( F = -6 \times 10^{-3} \sin(\omega t) \)

<table>
<thead>
<tr>
<th>( E' ) (GPa)</th>
<th>( Q_{\text{viscoel}} ) (Theo)</th>
<th>( Q_{\text{viscoel}} ) (Sim)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.1</td>
<td>30</td>
<td>30</td>
</tr>
<tr>
<td>0.4</td>
<td>7.5</td>
<td>7.5</td>
</tr>
<tr>
<td>0.8</td>
<td>3.7</td>
<td>3.7</td>
</tr>
</tbody>
</table>

- Harmonic vertical acceleration: \( a = 1g \)

Conclusions:

- The viscoelastic losses and the support losses have been determined by harmonic simulation in COMSOL
- The quality factors associated to viscoelastic losses obtained by COMSOL simulation are validated with analytical model
- The supports losses cannot be neglected for a low value of imaginary Young’s modulus of the viscoelastic polymer