CPW resonators
Noise and Decoherence vs Spin Echo
Xmon cQED

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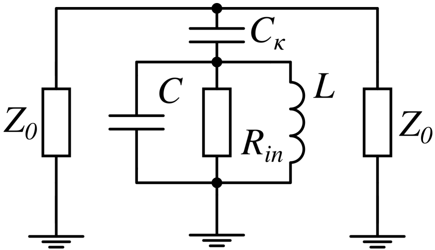
Capacitively coupled CPW resonator as a lumped-element model:



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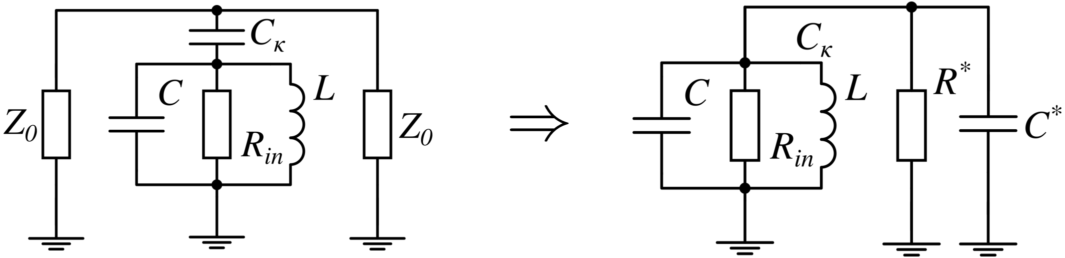

$$R^* = \frac{1+\omega^2 C_\kappa^2 (Z_0/2)^2}{\omega^2 C_\kappa^2 (Z_0/2)}, \quad C^* = \frac{C_\kappa}{1+\omega^2 C_\kappa^2 (Z_0/2)^2} \approx C_\kappa \text{ (for our case).}$$

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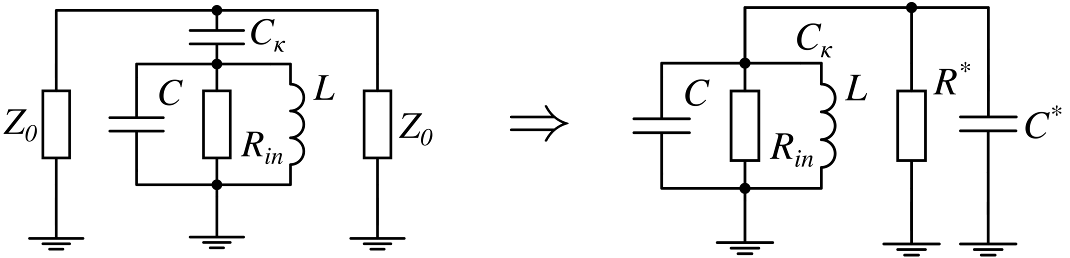
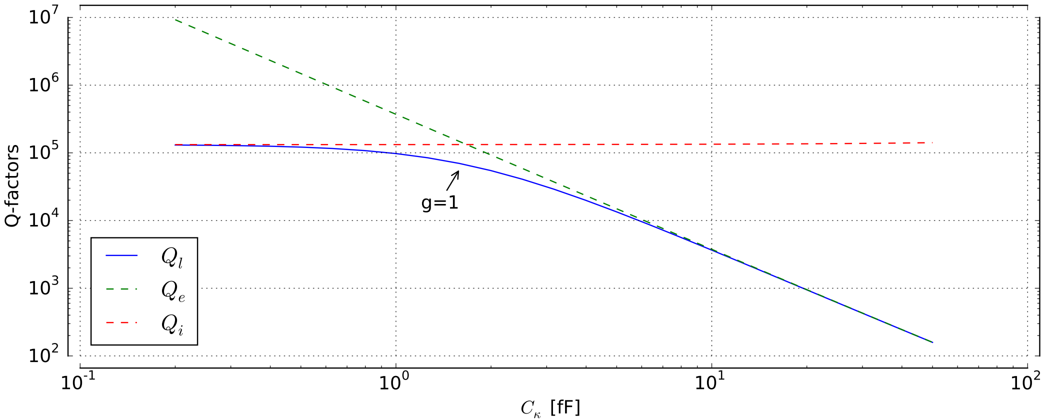
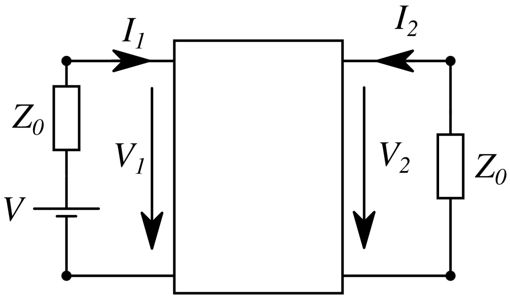


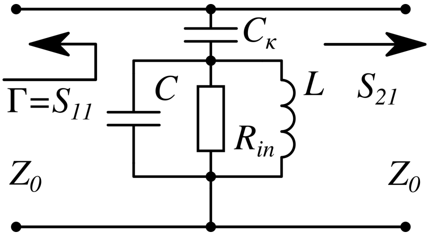
$$Q_i = \omega(C + C^*)R_{in}, \quad Q_e = \omega(C + C^*)R^*, \quad Q_l = \omega(C + C^*)\frac{1}{1/R^* + 1/R_{in}}.$$

Loaded, internal and external quality factors depending on C_κ:



General algorithm for calculating S-parameters of a given device:





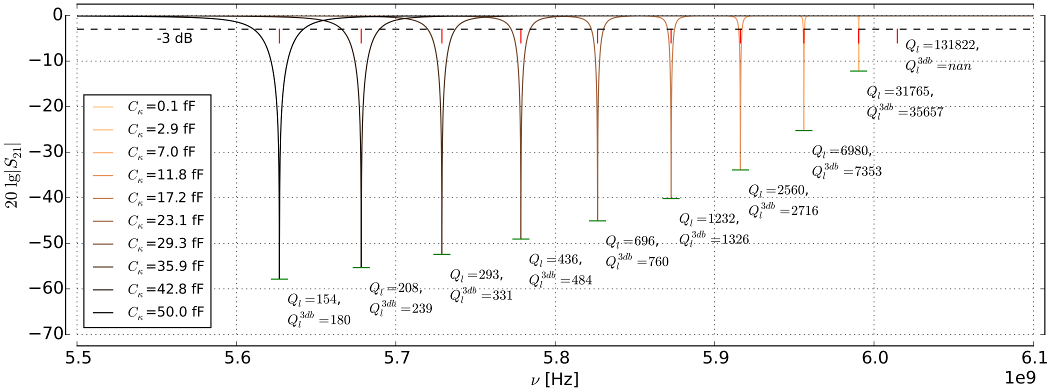
Kirchgoff's laws $\Rightarrow$

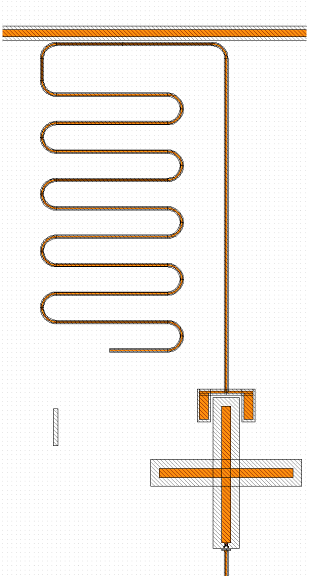
$$V_{1,2} = V_{1,2}^+ + V_{1,2}^-,$$

$$I_{1,2} = \frac{V_{1,2}^+ - V_{1,2}^-}{Z_0}$$

$$\Rightarrow \begin{pmatrix} V_1^- \\ V_2^- \end{pmatrix} = \begin{pmatrix} S_{11} & S_{12} \\ S_{21} & S_{22} \end{pmatrix} \begin{pmatrix} V_1^+ \\ V_2^+ \end{pmatrix}.$$

Transmission spectra for the shunting resonator depending on C_κ:





$l = \lambda/4$ coplanar resonators, $W = 4\,\mu m,\ G = 2\,\mu m$.

Unconventional coupling area:

$$C_\kappa^{eff} = C_\kappa \cos\frac{\pi x_\kappa}{2l}\ ?$$

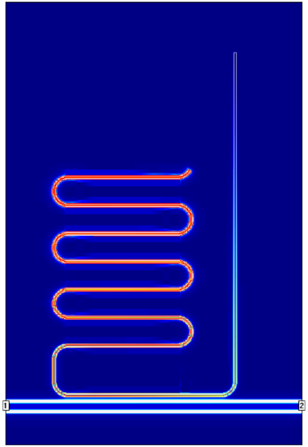
$$M_\kappa = ?$$

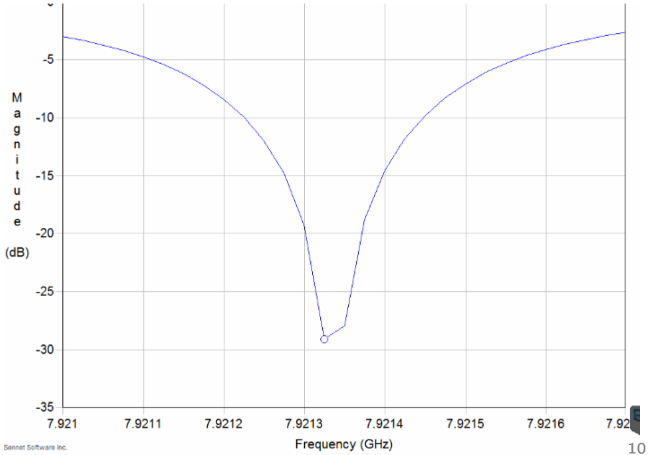
"Claw" coupler at the open end. Adds up some phase $\phi(\omega)$ and can be replaced by

$$\Delta l = \frac{\phi(\omega_r)c}{2\omega_r\sqrt{\varepsilon_{eff}}}$$

with extreme accuracy.

Resonator without a claw. Frequency expected from the length and C_κ (extracted from $Q_L \approx 10^4$) is 7.925 GHz.





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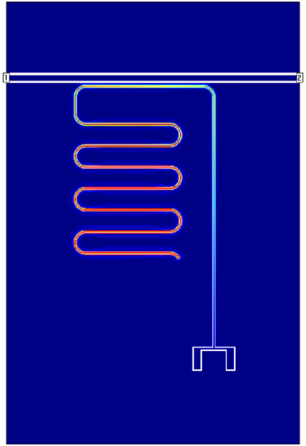
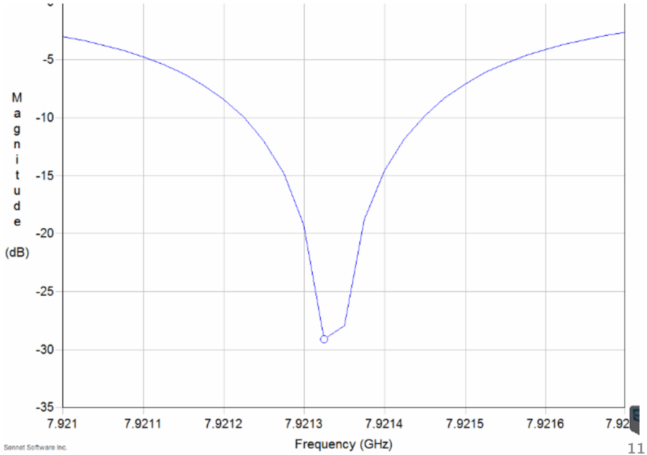
Resonator with a claw. Frequency expected from the previous simulation and ϕ (also simulated separately for the given claw) is 7.4255 GHz.





Quantum-mechanically treated dephasing

Noise and decoherence versus Hahn echo technique

Classically treated dephasing

Noise and decoherence versus Hahn echo technique

Noise PSD

Noise and decoherence versus Hahn echo technique

Who wins?

Noise and decoherence versus Hahn echo technique

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Eigenproblem for a qubit-resonator system

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Dispersive shifts

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