Exercise Class 5

Exercise 1

Consider a quantum harmonic oscillator with C = 200 fF, L = 50 nH. Calculate the single electron charging energy E_C, the inductive energy E_L, and the resonance frequency ω_0.

Exercise 2

Consider two quantum harmonic oscillators with C_1 = 700 fF, L_1 = 15 nH, and C_2 = 15 fF, L_2 = 700 nH. For each oscillator, estimate the uncertainties ΔN, $\Delta\varphi$ on the number of Cooper pairs N and superconducting phase φ for the state $|0\rangle$ and determine whether the oscillator would be most suited for a *charge* qubit or a *phase* qubit, neglecting leakage to the upper states.

Exercise 3

Consider an Al/Al_2O_3/Al Josephson junction ($\varepsilon_{Al_2O_3} = 9$) with critical current density J_0 = 10 A/cm^2, W = 2 μm, L = 1 μm, t = 1nm.

a. Calculate the equivalent capacitance C_J and minimum equivalent inductance L_{J0}.
b. Draw a quoted plot of the equivalent inductance $L_J(\varphi)$ as a function of the junction phase φ.

Exercise 4

Consider an Al/Al_2O_3/Al Josephson junction ($\varepsilon_{Al_2O_3} = 9$) with critical current density J_0 = 10 A/cm^2, W = 2 μm, L = 1 μm, t = 1nm. Estimate the frequencies of the $|0\rangle \rightarrow |1\rangle$ and $|1\rangle \rightarrow |2\rangle$ transitions.