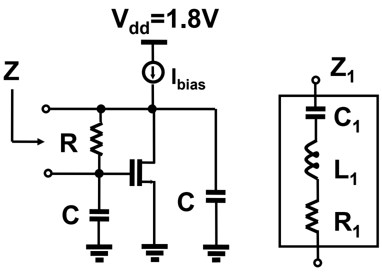
Tutorial T7

T7.1 Let us consider the crystal oscillator in figure, where $L_1 = 4.4$ mH, C_1 = 3.6 fF, R_1 = 30 Ω, C = 1 pF, R → ∞, V_t = 0.5V, $K = \frac{1}{2}\mu C_{OX}\left(\frac{W}{L}\right) = 2\ \mu A/V^2$ and Z_1 represents the equivalent impedance of an XTAL.



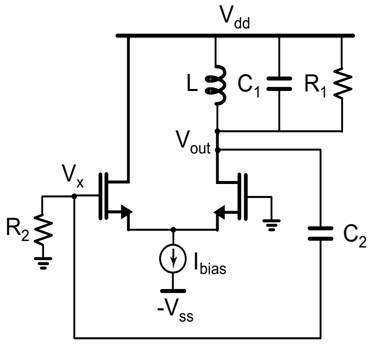
a) Derive the expression for Z(ω) as a function of the circuit parameters.

b) Evaluate oscillation frequency when the XTAL is connected in parallel to the previously evaluated impedance.

c) What is the minimum I_{bias} to guarantee start-up of the oscillation?

[Sol. a) $Z(j\omega) = \frac{2}{j\omega C} - \frac{g_m}{\omega^2 C^2}$; b) f_{osc} = 40MHz; c) I_{bias} = 0.45μA]

T7.2 Let us consider the oscillator in the figure, where V_{dd} = V_{ss} = 1.25V, V_t = 0.5V, $K = \frac{1}{2}\mu C_{OX}\left(\frac{W}{L}\right) = 10\ mA/V^2$, L = 4nH, C_1 = 0.5 pF, C_2 = 0.5 pF, R_1 = 1 kΩ, R_2 = 2 kΩ and I_{bias} = 3 mA.



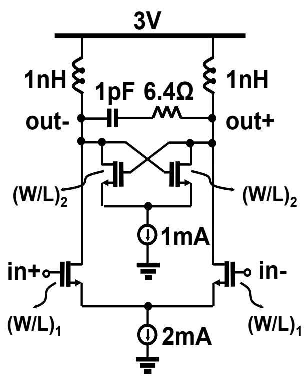
a) Making the necessary simplifications, derive the oscillation frequency and check the start-up condition.

b) Assuming full-switching of the differential stage, evaluate the oscillation amplitude at the output node, V_{out}.

c) Plot V_{out} and V_x over one period and check the operating region of the transistors.

[Sol. a) f_{osc} = 3.56 GHz, $|LG(f_{osc})| = g_m(R_1||R_2)/2$ = 2.58 > 1; b) $|V_{out}|$=1.27V; c) V_{out} = 1.25V + 1.27V·cos($\omega_{osc}t$), V_x = 1.27V·cos($\omega_{osc}t$)]

T7.3 Let us consider the circuit in figure, where V_t = 0.5V, $\frac{1}{2}\mu C_{OX} = 0.1\mathrm{mA/V^2}$ and $\gamma/\alpha = 2/3$.



a) Evaluate the resonant frequency of the differential load and find the values of $(W/L)_1$ and $(W/L)_2$ to obtain: (i) differential gain at resonance $(V_{out}^+ - V_{out}^-)/(V_{in}^+ - V_{in}^-)$ equal to 5dB and (ii) a -3dB bandwidth of the gain equal to 270MHz.

b) Considering both transistor and resistor noise, evaluate the output noise voltage spectral density at resonance.

c) Is there any limit on the choice of $(W/L)_2$? If so, explain why.

[Sol. a) $f_0 = 3.56$GHz, g_{m1} = 6mS, $(W/L)_1$= 90, g_{m2} = 2.9mS, $(W/L)_2 = 41$; b) $S_{V_{out}}^{(SSB)}(f_0)$ = (6.1nV/√Hz)^2; c) $(W/L)_{2,\max}$ = 205, to prevent oscillation.]