Low-power radio design for the IoT
Exercise 4 (24.03.2022)

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Problem 1 Low-power Common Source RF Design

The circuit in the Figure below is a single MOSFET Common Source (CS) Amplifier.

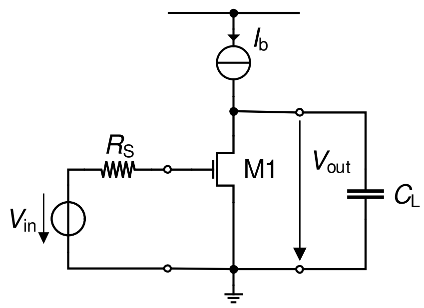

Figure 1: Common Source Amplifier.

- Find the optimum inversion coefficient of the common-source amplifier shown in **??** for maximizing the following figure-of-merit
$$FoM \triangleq \frac{\omega_u}{(F-1)\cdot I_b}. \tag{1}$$
- Calculate the bias current required to achieve a gain-bandwidth $f_u = 10\,GHz$ for a load capacitance $C_L = 10\,fF$ with $\lambda_c = 0.25$.
- Calculate the resulting noise factor F for a source impedance $R_S = 50\,\Omega$.
- How can you reduce this noise factor?

Problem 2 Common Source Design

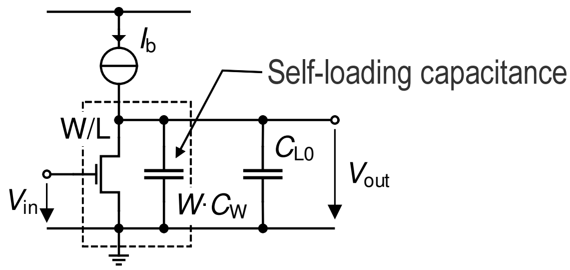

Figure 2: Common source amplifier including the self-loading capacitance.

The normalized bias current and aspect ratio for the CS amplifier

$$\begin{aligned} i_b &\triangleq \frac{I_D}{I_{spec\square}}\cdot\frac{1}{\Omega} = \frac{IC}{g_{ms}-\Theta}; \\ AR &\triangleq \frac{W}{L}\cdot\frac{1}{\Omega} = \frac{1}{g_{ms}-\Theta}, \end{aligned} \tag{2}$$

where $\Omega \triangleq \frac{\omega_u}{\omega_L}$ and Θ is equal to $\frac{C_w L}{C_{L0}} \cdot \frac{\omega_u}{\omega_L} = \frac{\omega_u}{\omega_{tspec}}$.

Design the CS amplifier, shown in Fig. 2, for the following specifications at room temperature:

$$f_u = 18\,\mathrm{MHz} \quad C_{L0} = 60\,\mathrm{fF} \quad V_{DD} = 1.8\,\mathrm{V} \quad L = 40\,\mathrm{nm} \quad C_w = 0.450\,\mathrm{fF/nm}, \tag{3}$$

and by assuming the following values for the technology parameters

$$I_{spec\square} = 950\,\mathrm{nA} \quad n = 1.5 \quad V_{T0} = 455\,\mathrm{mV} \quad \lambda_c = 0.4875 \quad L_{sat} = 19.5\,\mathrm{nm}. \tag{4}$$

- Find the IC_{opt}, the value of the inversion coefficient for which the bias current is minimum. Assume no velocity saturation.
- Based on the IC_{opt}, find the values of the bias current, I_q, and the transistor aspect ratio, W/L, to achieve the specified gain-bandwidth, ω_u.