UNIVERSITÄT PADERBORN
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FAKULTÄT FÜR ELEKTROTECHNIK, INFORMATIK UND MATHEMATIK

High-Frequency Electronics
Prof. Dr.-Ing. Andreas Thiede

Analog CMOS Integrated Circuits

Exercise 5: Differential Amplifier

1. Prove, that the term $\frac{4 \cdot I_{SS}}{\mu \cdot C_I \cdot \frac{W}{l}} - \left(V_{IN1} - V_{IN2}\right)^2$ under the square root in equation

$$I_{D1} - I_{D2} = \frac{1}{2} \cdot \mu \cdot C_I \cdot \frac{W}{l} \cdot \left(V_{IN1} - V_{IN2}\right) \cdot \sqrt{\frac{4 \cdot I_{SS}}{\mu \cdot C_I \cdot \frac{W}{l}} - \left(V_{IN1} - V_{IN2}\right)^2} \qquad \text{(II.1)}$$

can't become zero !

2. Derive the formula for the conversion gain

$$A_{cm-diff} = \frac{v_{out1} - v_{out2}}{v_{in,cm}} = -\frac{\Delta g_m}{1 + \left(g_{m1} + g_{m2}\right) \cdot R_{SS}} \cdot R_D \qquad \text{(II.2)}$$

in case of asymmetric transconductances $g_{m1} = g_m + \Delta g_m$, $g_{m2} = g_m$!

3. Determine intuitively the differential small signal gain of the depicted amplifier !
Neglect body effect and channel length modulation !