Krummenacher loop for large signal; calculation of the discharge current

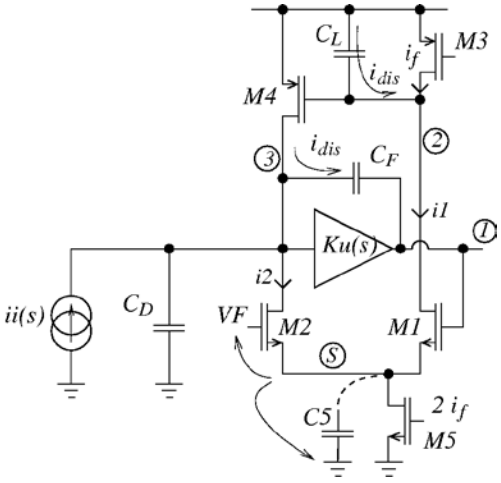

Fig1. Krummenacher feedback for n+-on-p- detectors. Large signal analysis.

Assuming that M2 and M1 are in weak inversion one can write the expression for its drain currents as:

$$i_{1,2} = A \cdot \exp\left(\frac{v_{gs1,2}}{n \cdot U_t}\right)$$ where A is the technological constant depending also on the transistor dimensions, U_t is thermal voltage and v_{gs} is gate source voltage.

For the fast signal analysis and neglecting the leakage current, the discharge current i_{dis} flowing through feedback capacitor C_F has to be supplied to M1 from the capacitor C_L (differential pair operation). Current flowing through M4 is constant and equal to i_f (C_L is holding the v_{gs} of the M4 for fast changing signals). Sum of the currents at nodes 2 and 3 gives:

$$i_f + i_{dis} = i_1 \qquad and \qquad i_2 = i_f - i_{dis}$$

Knowing that $v_{gs1} - v_{gs2} = v_{out} \qquad (signal\ minus\ DC)$

and combining all above expression one can derive the expression for i_{dis} as a function of output voltage:

$$i_{dis} = i_f \cdot \mathrm{Tanh}\left(\frac{v_{out}}{2 \cdot n \cdot U_t}\right)$$