\[ V_i = V_0 = \frac{V_i}{A} \]

\[ V_{in} = \frac{V_i + V_o}{2} \]
\[ V_{out} = \frac{V_i - V_o}{2} \]

\[ A_c = \frac{V_o}{V_i} \]
\[ T = \frac{V_o}{V_i} = \frac{1}{1 + AF} \]

\[ A = \frac{V_o}{V_i} = \frac{1}{1 + AF} \]

\[ C_m = \frac{1}{1 + A} \]
\[ R_o = R_{in} \parallel R_{c} = R_{in} \]
\[ R_{dc} = \frac{1}{2} \]

\[ V_{out}^2 = \frac{R_o}{R_{in}} \]
\[ A_c = \frac{R_o}{R_{in}} \]

\[ R_{in} = \frac{1}{2} \]
\[ R_{out} = \frac{1}{2} \]

\[ \text{Gain:} \quad A = \frac{V_o}{V_i} \]

\[ \text{Closed-loop gain:} \quad T = \frac{V_o}{V_i} = \frac{1}{1 + AF} \]

\[ \text{Input impedance:} \quad R_{in} = \frac{1}{2} \]

\[ \text{Output impedance:} \quad R_{out} = \frac{1}{2} \]
Differentiel gain

Easy, using false assumption: \( V_{tail} \) is virtual rail.

\[
\frac{V_{id}}{2} + i_o \quad G_m = \frac{i_o}{V_{id}} \quad V_{o=0} = 0
\]

\[
i_o = B \cdot d_1B + d_2B
\]

\[
d_1B = 5mB \cdot (-\frac{V_{id}}{2})
\]

\[
d_2B = 9m2B \cdot V_{g32b}
\]

\[
V_{g32b} = A_{V LEFT} \cdot \frac{V_{id}}{2} = -9m1A \cdot \frac{V_{id}}{2}
\]

for two stage, both common mode and differential mode

increase by \( A_{V2} \)

so CMRR stays the same.

Input common mode range

\[
V_{TP} + V_{OU2}
\]

\[
V_{CM\text{ min}} = V_{OU3} + V_{EN} + V_{OU1}
\]

\[
V_{CM\text{ max}} = V_{DD} - (V_{TP} + V_{OU2}) + V_{EN}
\]

\[
V_{CM\text{ max}} = \frac{V_{DD}}{2} - V_{TP} - V_{OU2} + V_{EN}
\]
2-stage input common mode: same as single-stage

2-stage output swing: independent of input common mode

correct short of some 1-to-1

correct mixer of any 1-to-2 stage as 2-stage

4: (\frac{2}{3})^2\frac{1}{2} = \frac{2}{5}

\text{Input: } I_{\text{in}} = I_{\text{bias}} + I_{\text{out}}

\text{Output: } I_{\text{out}} = I_{\text{bias}} + I_{\text{load}}

\text{For } I_{\text{bias}} = \frac{1}{2} I_{\text{load}}

\text{Need to scale appropriately}

\text{Input: } \frac{2}{5} L = \frac{2}{5} R

\text{Output: } \frac{3}{5} L = \frac{3}{5} R