Fully differential circuits:

\[ V_{cm} = \frac{V_{o1} + V_{o2}}{2} \leftarrow \text{Average} \]

Differential signal: \[ V_d = V_{o1} - V_{o2} \leftarrow \text{Difference} \]
(+) Rejects any CM disturbances

\[ \rightarrow V_{DD} \text{ and noise} \]

\[ \rightarrow \text{capacitively coupled noise} \]

(+) 2X Signal Swing

\[ \rightarrow 6 \text{dB more signal power} \]

\[ \rightarrow 3 \text{dB increase in noise} \]

\[ \Rightarrow 3 \text{dB gain in SNR} \]

(+) get rid of even-order non-linearity.
Differential circuit

\[ V_{out} = \frac{f\left(\frac{V_{in}}{2}\right) - f\left(-\frac{V_{in}}{2}\right)}{V_{o1} - V_{o2}} \]

\[ j_{odd} = \frac{f(x) - f(-x)}{2} \quad \text{<-- odd } f \text{ doesn't have even order term} \]

\[ = a_1x + a_3x^3 + a_5x^5 \]

\[ j_{even}(x) = \frac{f(x) + f(-x)}{2} \quad \Rightarrow \text{CM output level} \]
Half-Circuit Analysis & Razavi

\[ V_c = V_{in_1} - V_{in_2} \]

Differential / Half-Circuit

Differential Half-Circuits:

\[ A_{DM} = -g_m \left( \frac{R_o}{1/g} \right) \]

\[ + \frac{V_a}{2} \]

\[ - \frac{V_a}{2} \]
\[ A_{v,cm} = - \frac{R_0/2}{(r_{2pm}) + R_{ss}} \]
differential
negative feedback
Can never have two "Independent" current sources fight to set a node voltage.
CMFB loops

Desired CM-level at the output

ΔI → 0 by the CMFB

Common-mode feedback loop

→ V_{CM} → V_{om, ref}

& I_{mos} = I_{ymos}
-ve feedback loop to set the output CM level.

\[ V_{0,om} = \frac{V_{op} + V_{om}}{2} \]

* The CMFB loop shouldn't disturb the differential picture