2 stage review

uncompensated

\[ V_{in} = \frac{R_1}{R_2} \]

\[ V_{out} = \frac{V_{ref}}{R_2} \]

\[ I_{out} = \frac{V_{ref}}{R_2} \]

\[ V_{supply} = V_{in} + V_{ref} \]

Weed a reference current/voltage

Load current

\[ I_{load} = \frac{V_{in} - (V_{in} + V_{ref})}{R} \]

2 stage wrap up

supply indep. biasing

\[ V_{out} = \frac{V_{ref}}{R_2} \]

\[ V_{supply} = V_{in} + V_{ref} \]

Weed a reference current/voltage

Load current

\[ I_{load} = \frac{V_{in} - (V_{in} + V_{ref})}{R} \]

Weld like test to see independent of

Process Voltage

Temperature

-40°C to +85°C
Cons 5m bias circuit

\[ I_1 = \frac{M_{ox}(\frac{W}{L})}{2} (V_{ov1})^2 \]

\[ I_2 = M_{ox} K (\frac{W}{L}) (V_{ov1} - I_2 R)^2 \]

If \( I_2 R \ll V_{ov1} \), then \( I_D \approx \frac{1}{R} \frac{I_{D_1}}{I_{D_2}} \)

\[ \frac{V_{ov1}}{V_{ref}} + \frac{I_2 R}{V_{ref}} = \frac{V_{ov1}}{V_{ref}} \]

\[ I_2 R = (1 - \frac{1}{\sqrt{K'}}) V_{ov1} \]

\[ K = 4 \implies I_2 R = \frac{1}{2} V_{ov1} \]

\[ V_{ov1} = V_{ov1} - I_2 R = \frac{1}{2} V_{ov1} \]

\[ \frac{S_{m1}}{V_{ov1}} = 2 \frac{I_{D_1}}{2 I_{D_2}} R = \frac{1}{R} \]

"constant \( S_m \)" biasing index \( M_{ox}(x, V_{DD}) V_{DD} \)

Use long-channel devices
- Often cascade to improve supply rejection (we ignored \( 1 + \lambda V_{DS} \))