Tail Current Source Resistance in Common-Mode Gain of Diff. Amplifier

Dr. Anil Kumar Gundu

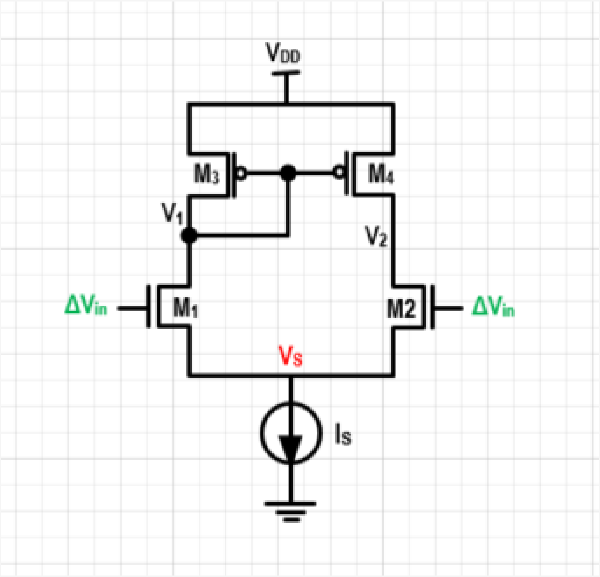
Role of Tail Current Source Resistance in Common-Mode Gain (I)

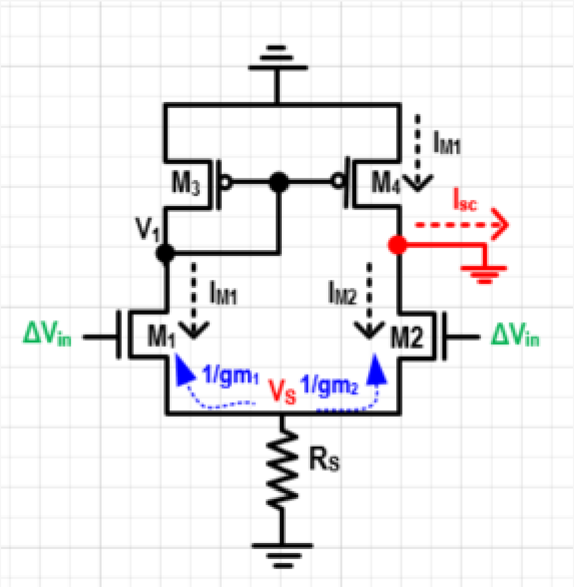
What is the impact of the tail current source's finite output resistance on the common-mode gain of a differential amplifier employing an active and perfectly matched current mirror if :

(i) the channel length modulation (CLM) of M1 – M4 are zero

(ii) The channel length modulation of M1, M2 is zero but the channel length modulation of transistors M3 and M4 is non-zero

Case (i) : The common-mode gain remains zero when the channel length modulation (CLM) of M1, M2, M3, and M4 is zero, even with a finite output resistance in the tail current source. This is because identical currents through M1 and M2 result in a zero short-circuit current, as the current mirror (M3–M4) replicates this current. Thus, zero transconductance (Gm) leads to a zero common-mode gain.





$$I_{M1} = I_{M2} = \frac{g_m}{1+2g_mR_s}\Delta V_{in}$$

$$I_{M3} = \frac{g_m}{1+2g_mR_s}\Delta V_{in}$$

If M3 and M4 matched perfectly

$$I_{M4} = \frac{g_m}{1+2g_mR_s}\Delta V_{in}$$

$$I_{sc} = 0$$

Role of Tail Current Source Resistance in Common-Mode Gain (II)

What is the impact of the tail current source's finite output resistance on the common-mode gain of a differential amplifier employing an active and perfectly matched current mirror if :

(i) the channel length modulation (CLM) of M1 , M2, M3, and M4 are zero

(ii) The channel length modulation of M1, M2 is zero but the channel length modulation of transistors M3 and M4 is non-zero

Case (ii) : IM1 spilts between ro3 and 1/gm3. A fraction of current mirrored to M4 and hence the structure exhibits transconductance. The ouput impedence looking into the output is ro4 (M1 and M2 exhibits zero CLM) which eventually lead to a negative common-mode gain. To mitigate this, the transconductance multiplied by a source resistance (2gmRS) should be significantly larger than 1, implying that the sizing of input devices like M1 and M2 needs to be larger than that of the tail current source.