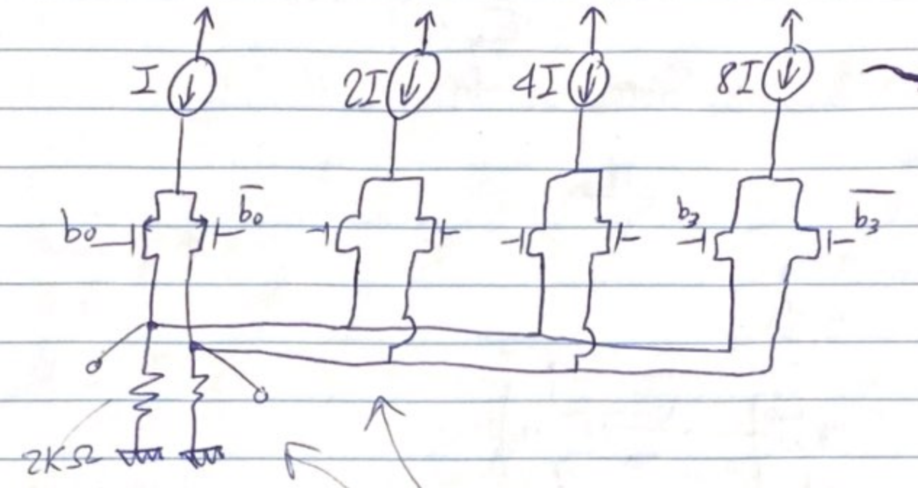
1 Binary weighted DAC:

MSB / LSB
$b[3:0]$



→ Cascode, High swing

2 Segmented:

	MSB		LSB
	2	+	2

(4I 4I 4I) (2I I)

$b_1\ b_0$ → same

b_3	b_2	
0	0	all off
0	1	1 on
1	0	2 on
1	1	3 on

→ decoder

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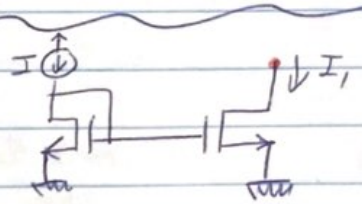
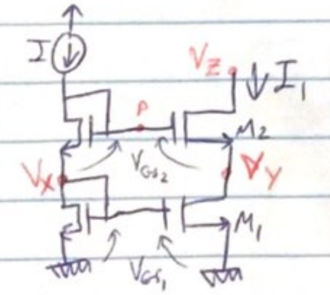
* Current source



$$I_1 = \frac{1}{2}\mu_n C_{ox} \frac{W}{L}(V_{GS}-V_t)(1+\lambda V_{DS})$$

↓

Cascode



$R_o = (g_{m_2} r_{o_2}) r_{o_1}$

$V_{\cancel{X}} = V_{GS_1} \cong V_Y$

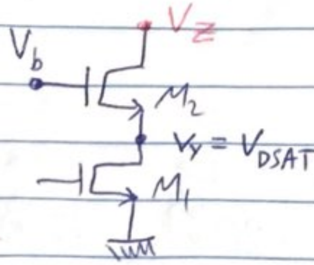
$V_P = V_{GS_1} + V_{GS_2}$

$V_Z = V_Y + V_{DSAT}$

$= V_{GS_1} + V_{DSAT}$ → Too big (decrease Headroom)

* as $V_Z \downarrow$, one of M_1 or M_2 will come out of saturation, decreasing R_o.

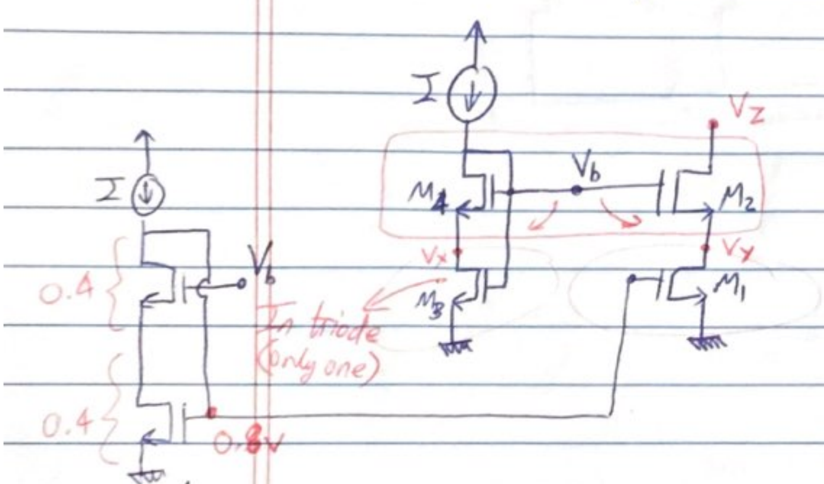
High Swing Cascode



ex $V_{DSAT} = V_{GS} - V_{TH}$
$= 0.1V$
$V_{TH} = 0.4V$

I choose V_b such that $V_Y = V_{DSAT}$

$\therefore V_Z = 2V_{DSAT}$



* I want current density of M_4 & M_2 is the same

$$\frac{I_D}{\left(\frac{W}{L}\right)} = \frac{1}{2}\mu_n C_{ox}(V_{gs} - V_{th})^2$$

$\therefore V_{gs_4} = V_{gs_3}$

* I adjust

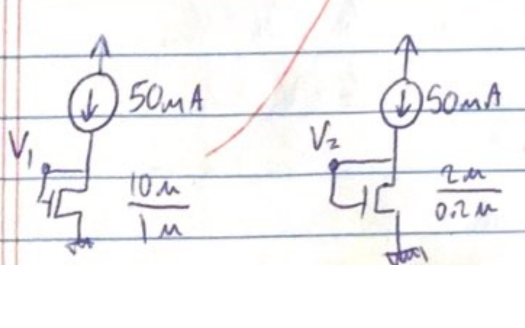
$$I_D = \frac{1}{2}\mu_n C_{ox}\left(\frac{W}{L}\right)(V_{gs} - V_{th})^2$$

by adjusting I_D & $\frac{W}{L}$, you get V_{gs}

⇨ Monte Carlo

$$\Delta V_{th} = \frac{A_{Vt}}{\sqrt{WL}}$$

we want $5\sigma < \frac{1}{8}$ LSB



$\sigma_{V_1} << \sigma_{V_2}$

V_1 has less variation ($\sigma_{V_1} = \frac{1}{5}\sigma_{V_2}$)