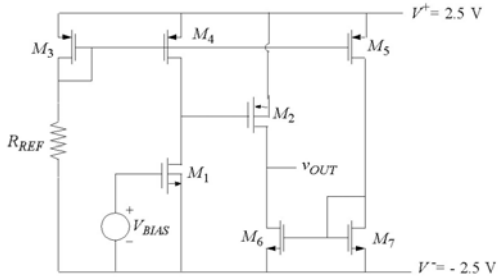
Output Voltage Swing



Transistors M_2 and M_6 will limit the output swing

Limits to Output Voltage

M_6 will leave saturation when v_{OUT} drops to:

$$v_{OUT,MIN} = V^- + V_{DS6,sat} = -2.5 + \sqrt{\frac{2I_{D6}}{\mu_n C_{ox}(W/L)_6}}$$

$v_{OUT,MIN}$ = -2.5 + 0.28 = - 2.22 V

M_2 will leave saturation when v_{OUT} rises to:

$$v_{OUT,MAX} = V^+ - V_{SD2,sat} = 2.5 - \sqrt{\frac{2(-I_{D2})}{\mu_p C_{ox}(W/L)_2}}$$

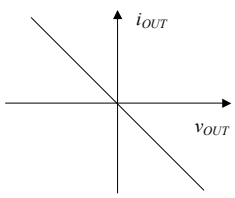
$v_{OUT,MAX}$ = 2.5 - 0.32 = 2.18 V

What about M_4?

Output *Current* Swing

Load resistor: pick $R_L = 25$ kΩ

Output current: $i_{OUT} = -v_{OUT} / R_L$



$$\boxed{i_{OUT} = i_{D6} - (-i_{D2})}$$

Limits: asymmetrical

M_2: can increase - i_{D2}

M_6: can't increase i_{D6}

Output Current Limits

- Positive output current (negative v_{OUT})

$$i_{OUT,MAX} = i_{D6} - (0) = 50\mu A = -v_{OUT,MIN} / R_L$$

$$v_{OUT,MIN} = -(50\mu A)(25k\Omega) = -1.25V$$

(less negative than limit set by saturation of M_6)

- Negative output current (positive v_{OUT})

No limit on current from M_2, so voltage swing sets current limit

$$i_{OUT,MIN} = -v_{OUT,MAX} / R_L = -(2.18V / 25k\Omega) = -87.2\mu A$$

Transfer Curves (for R_L = 25 kΩ)

Loaded voltage gain = v_{out}/v_{in} = $(g_{m1}R_{out1})(g_{m2}R_{out}||R_L)$ = 490

Loaded transconductance = i_{out}/v_{in}
= $(-g_{m1}R_{out1})(g_{m2})(R_{out}/(R_{out} + R_L)$ = -19.5 mS