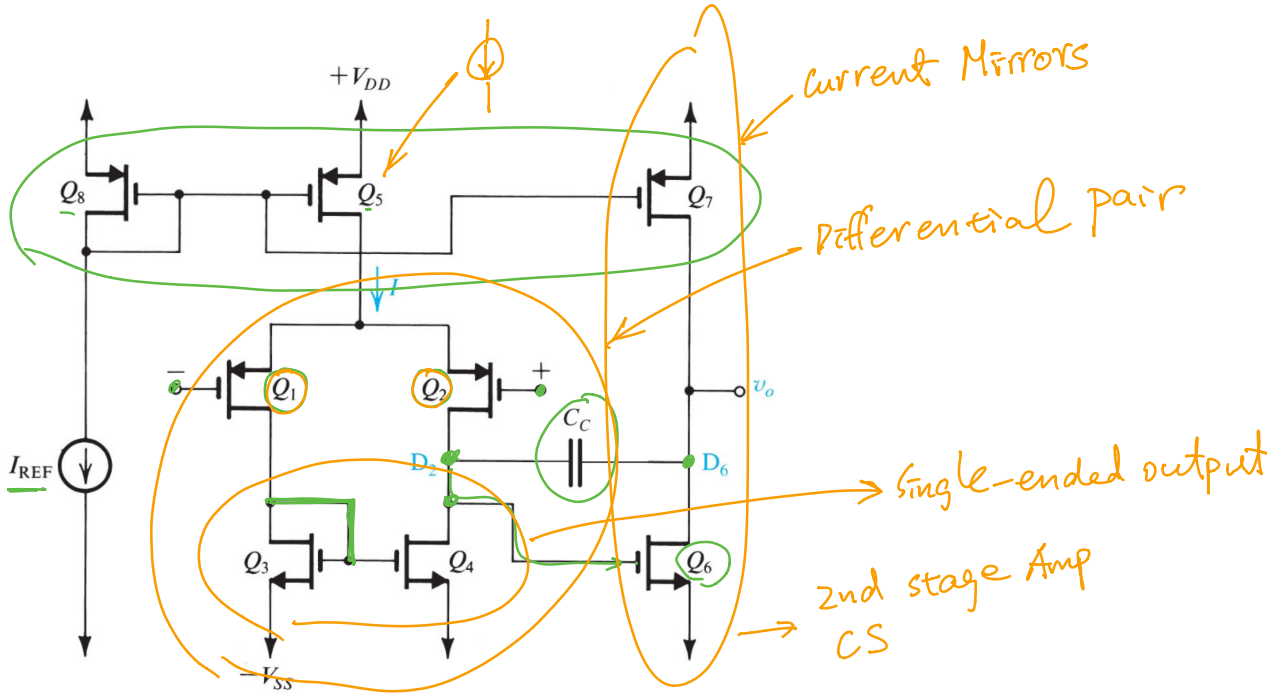
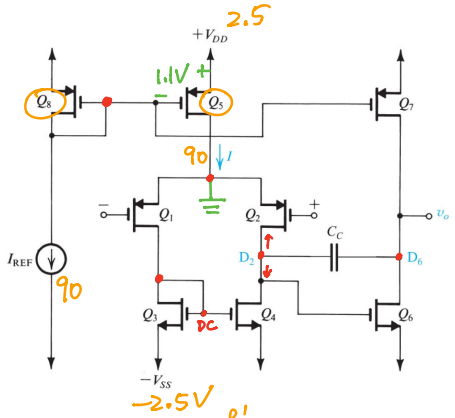


Q_3, Q_4 : active load

$\Rightarrow$ convert differential output to single-ended



	Q1	Q2	Q3	Q4
W/L in um	20/0.8	20/0.8	5/0.8	5/0.8

	Q5	Q6	Q7	Q8
W/L in um	40 4/0.8	10/0.8	40 4/0.8	40 4/0.8

I_{REF} = 90 µA, V_{tn} = 0.7V, V_{tp} = -0.8V
$\mu_n C_{ox}$ = 160 µA/V², $\mu_p C_{ox}$ = 40 µA/V² k_p'
$|V_A|$ = 10V for all devices
$V_{DD} = V_{SS}$ = 2.5V

$|V_A| = \frac{1}{\lambda} \Rightarrow \lambda = 0.1\ V^{-1}$

Find I_D, $|V_{OV}|$, $|V_{GS}|$, g_m, r_o for all Q's,
voltage gain,
input common mode range,
output voltage range.

$I_1 = 45\times10^{-6} = \frac{1}{2}\times 40\times10^{-6}\left(\frac{20}{0.8}\right) V_{OV1}^2$

$V_{OV1}^2 = \frac{90\times0.8}{40\times20} = 0.09 \Rightarrow V_{OV1} = 0.3V$

$V_{OV2} = 0.3V$

$\left(\frac{W}{L}\right)_3 = \frac{1}{4}\left(\frac{W}{L}\right)_1$, $k_n' = 4\times k_p'$

$\Rightarrow V_{OV3} = V_{OV4} = 0.3V$

$\left(\frac{W}{L}\right)_6 = 2\left(\frac{W}{L}\right)_3$, $I_6 = 2\times I_3$

$\Rightarrow V_{OV6} = 0.3V$

$\left(\frac{W}{L}\right)_7 = 2\left(\frac{W}{L}\right)_1$, $I_7 = 2\times I_1 \Rightarrow V_{OV7} = 0.3V$

$V_{OV5} = V_{OV8} = 0.3V$

$V_{GS3,4,6} = V_{OV} + V_{tn} = 0.3 + 0.7 = 1V$

$|V_{GS1,2,5,7,8}| = |V_{OV}| + |V_{tp}| = 0.3 + 0.8 = 1.1V$

$A_{V1} = g_{m1}(r_{O2} /\!/ r_{O4})$

$A_V = -g_{m6}(r_{O6} /\!/ r_{O7})$

$g_{m1} = k_p V_{OV1} = k_p'\left(\frac{W}{L}\right)_1 V_{OV1} = 40\times10^{-6}\times\left(\frac{20}{0.8}\right)\cdot 0.3 = 0.3\times10^{-3}$

$g_{m6} = k_n V_{OV6} = 160\times10^{-6}\times\left(\frac{10}{0.8}\right)\cdot 0.3 = 0.6\times10^{-3}$

$r_{O2} = \frac{V_A}{I_2} = \frac{10}{45\times10^{-6}} = 220\times10^3$

$r_{O4} = 220\times10^3$

$r_{O6} = \frac{V}{I_6} = 110\times10^3 = r_{O7}$

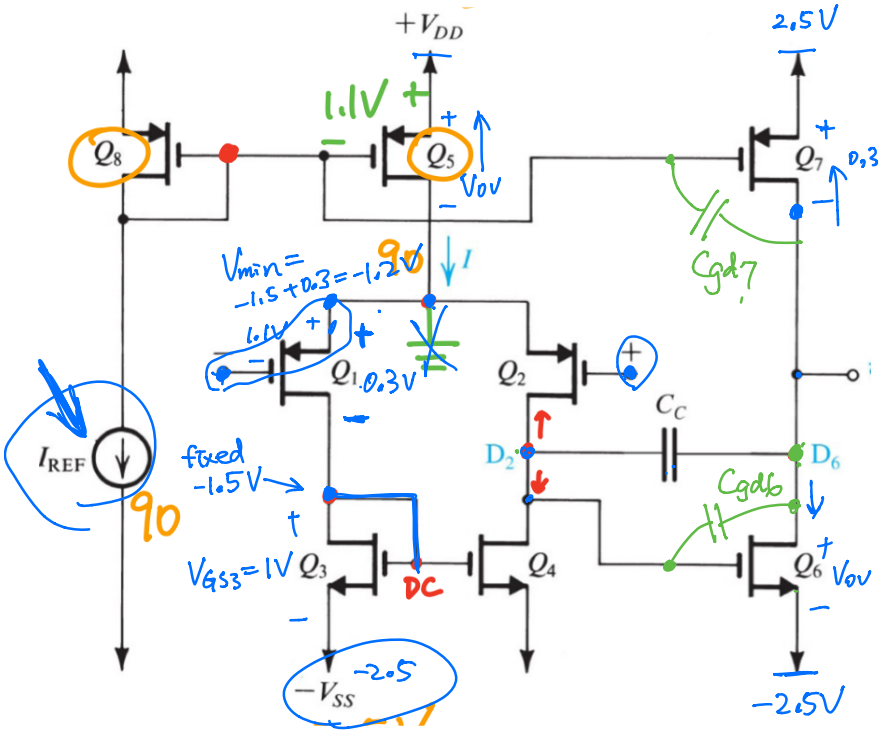
$A_V = A_{V1}\cdot A_{V2} = \left(0.3\times\frac{220}{2}\right)\times\left(0.6\frac{110}{2}\right) = -1.1\times10^3\ \frac{V}{V}$

$20\times\log|A_V| = 61\ dB$ #

$R_{out} = r_{O6} /\!/ r_{O7} = \frac{110k\Omega}{2} = 55\ k\Omega$ #

D_2 node: $R_{D2} = r_{O2} /\!/ r_{O4} = 110k\Omega$

D_6 " : $R_{D6} = r_{O6} /\!/ r_{O7} = 55k\Omega$



$V_{out,max} = 2.5 - 0.3 = 2.2V$

$V_{out,min} = -2.5V + 0.3 = -2.2$

Common Mode Input

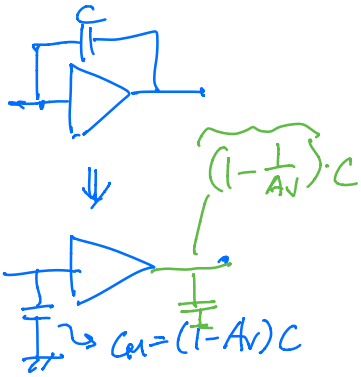
$V_{CM,max} = 2.5 - 0.3 - 1.1 = 1.1\ V$

$V_{CM,min} = -1.2 - (1.1) = -2.3\ V$

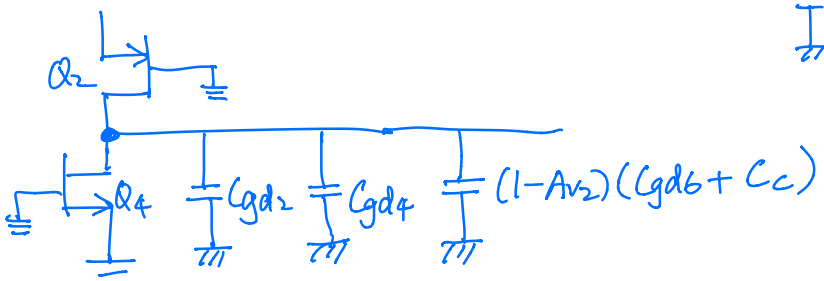
$|V_{GS1}|$

Cap. at P_6

$C_6 = C_{gd7} + (C_{gd6} + C_c)$



Cap at P_2:



Dominant Pole is at P_2

$\tau \cong \tau_2 = (r_{O2} // r_{O4})(C_{gd2} + C_{gd4} + (1 - A_{V2})(C_{gd6} + C_c))$

$\parallel$

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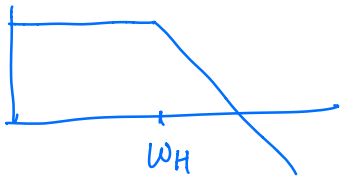
$\omega_H = \frac{1}{\tau_2} \Rightarrow f_H = \frac{1}{2\pi}\omega_H$



741 Op-Amp Circuit