(1)

Problem 4 Soln:

1) $Q_1 - Q_4$ Have 45 μA drain current

$g_m = 0.3\ mA/V^2$

$r_o = 222\ k\Omega$

$Q_5 - Q_8$ Have 90 μA drain current

$g_m = 0.6\ mA/V^2$

$r_o = 111\ k\Omega$

$$A_{v_1} = -g_{m1}(r_{o2} \| r_{o4}) = -0.3\,(222 \| 222) = -33.3\ V/V$$

First stage

$$A_{v_2} = -g_{m6}(r_{o6} \| r_{o7}) = -33.3\ V/V$$

second stage

Total gain $|A_v| = 1109\ V/V$

2) Output can go from:

$$-V_{SS} + |V_{ov}| \le V_o \le V_{DD} - |V_{ov}|$$

$$-2.5 + 0.3 \le V_o \le 2.5 - 0.3$$

$$-2.2 \le V_o \le 2.2$$

Input, common mode is more restrictive:

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~~$-V_{SS} + V_{ov} \le V_{in} \le V_{DD} -$~~

~~$-V_{SS} + V_{tn} + V_{ov} + |V_{ov}| \le V_{in}$~~

Problem 4 Soln, cont'd

$$-V_{SS} + V_{tn} + V_{ov} + V_{ov} - |V_{tp}| - V_{ov} \leq V_{in} \leq V_{DD} - |V_{tp}| - V_{ov} - V_{ov}$$

$$-2.5 + 0.7 + 0.3 - 0.8 \leq V_{in} \leq 2.5 - 0.8 - 0.3 - 0.3$$

$$-2.3 \leq V_{in} \leq 1.1\,V$$

Taking the worse of these limits

$$-2.2\,V \leq V \leq 1.1\,V$$

3) Gain of second stage is -33.3

Miller Mult. factor is 34.3

$$C_M = 8 \cdot 34.3\ pF =$$

$$= 2.74 \times 10^{-10}\ F$$

$$\omega_p \cong \frac{1}{(r_{o2} \| r_{o4})\, C_M} = 3.28 \times 10^4\ r/s$$

$$(5\ kHz)$$

4 Slew Rate

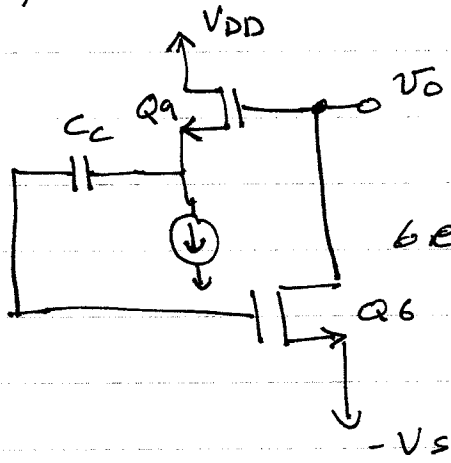
$$\frac{dV_c}{dt} = \frac{I}{C_c} = \frac{90 \times 10^{-6}}{8 \times 10^{-12}} = 1.13 \times 10^7\ V/s$$

$$(11.3\ V/\mu s)$$

(3)

Problem 4, cont'd

5 Connecting the source follower:



Now V_o has to be greater than

$-V_{ss} + V_{ov} + V_{tn}$

$= -2.5 + 0.3 + 0.7$

$= -1.5$

It further restricts the output making the total follower range:

$$-1.5V \leq V \leq +1.1V$$