Lab 6 prelab

Wednesday, September 25, 2024 21:39

MOSFET OP AMP

- differential inputs – wide range of common mode inputs
- very large open-loop gain – negative feedback networks to create amplification + filtering circuits independent of op amp design
- very large input impedence – prevents loading 'high impedence' outputs (accuracy not lost)
- low output impedance – enables driving small impedance loads without loss of linearity/accuracy
- High bandwidth – allows amplification of high frequency signals

Negative feedback network can control system's gain + bandwidth
– circuits can also be easily cascaded

input $\pm$ → Differential gain → voltage gain → current gain → output

- ideal opamp has infinite open loop gain

common source amp

$A_v = g_{m8}(r_{o8} || r_{o4})$

$r_{out} = r_{o8} || r_{o4}$

Lowering output impedance: Source follower

Source follower = common drain amplifier
– provides amplifier with current gain | reduce output impedance so amplifier can deliver more current with less V drop

assuming Q7 in sat in fig 6.5:

$V_S = V_{in} + V_{SG} = V_{in} + \sqrt{\frac{I_D}{\frac{W}{2L}K'}} + |V_{th}|$

tracks input voltage with offset V_{th}
- Source voltage "follows" the input voltage

Source follower gain

$A_V = \frac{V_{out}}{V_{in}} = \frac{g_m(r_o || R_{source})}{1 + g_m(r_o || R_{source})}$

as long as $g_m(r_o || R_{source}) \gg 1$
→ gain will approx be $A_V = 1V$
(if transistor in sat & has high k')

source follower output resistance

$r_{out} = \frac{1}{g_m}$

Final design: Op amp

Satisfies: provides differential input
overall gain exceeds 60 dB
input resistanes nearly ∞
output impedance reasonably low

this diagram is scuffed as hell, sorry.

Prelab Questions

1. Small signal model for entire opamp

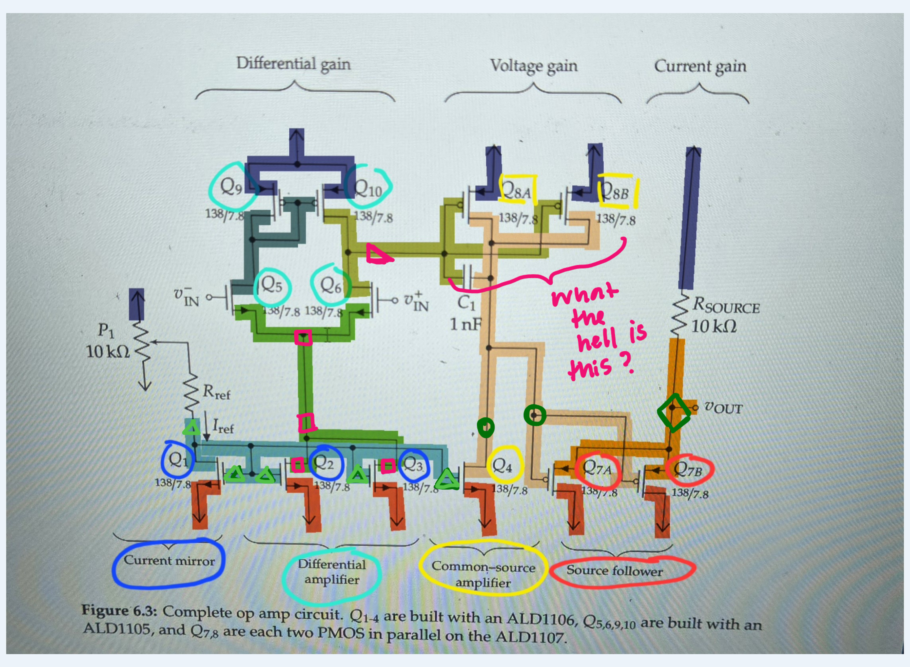
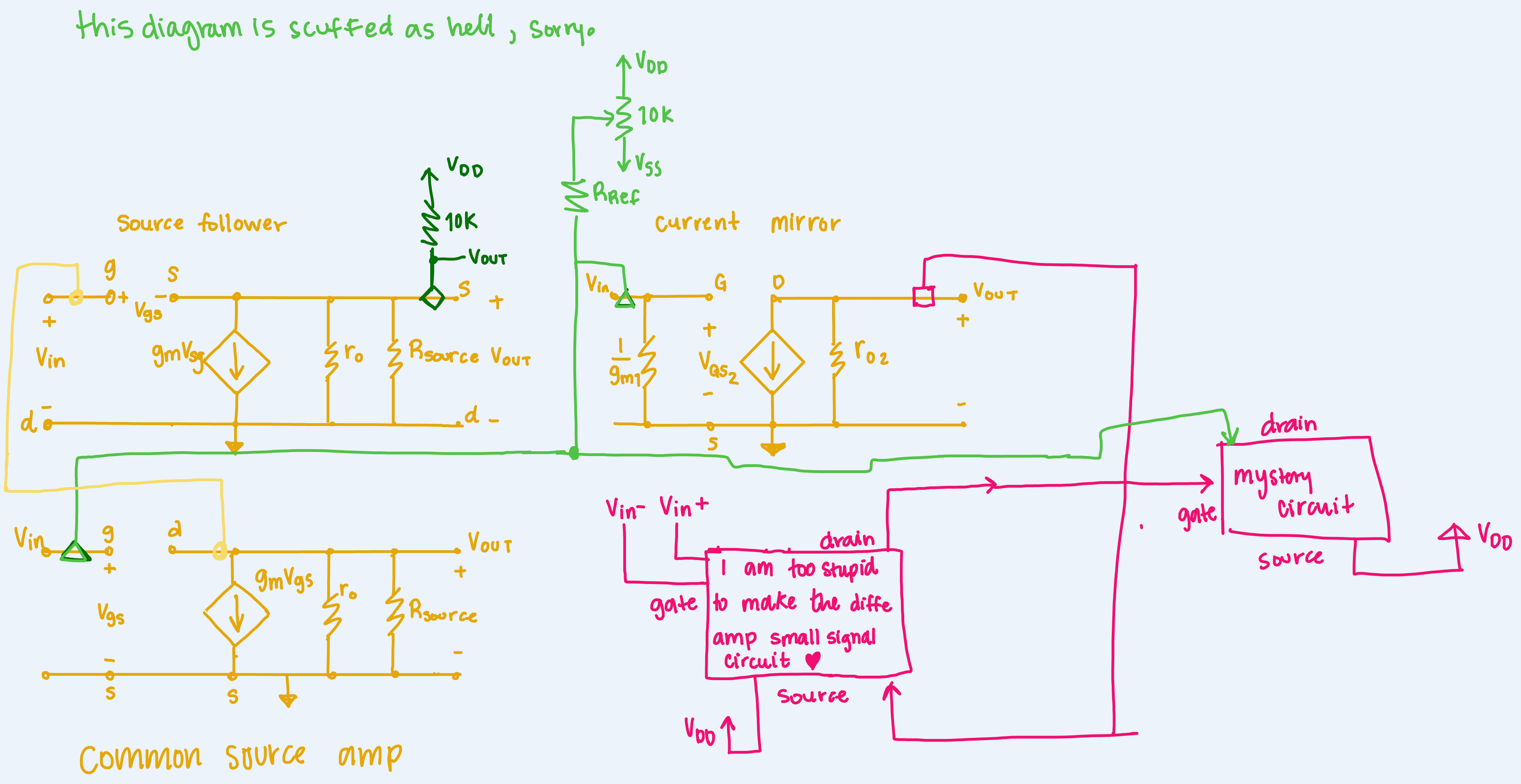


Figure 6.3: Complete op amp circuit. Q_{1-4} are built with an ALD1106, $Q_{5,6,9,10}$ are built with an ALD1105, and $Q_{7,8}$ are each two PMOS in parallel on the ALD1107.



Common source amp

2. Open loop gain without source follower
→ in terms of transistor params + Iref

Current Mirror: Q 1 - 3
Differential Amp: Q 5, 6, 9, 10
CS Amp: Q_4 & Q8A-B
Source follower: Q7A - 7B

◇ Diffe Amp Gain

Q_5 & Q_6: Input ($V_{in\pm}$ input signals)
– amplifies difference in the 2 inputs
Q_9 & Q_{10}: active load
– high output impedance (more V gain)

$A_{V(Diffe\ Amp)} = g_{m5}(r_{o6} || r_{o9})$

◇ CS Amp Gain
– just Q_4 ◡̈ yay!

similar to page 68 on the manual

$A_{V(CSA)} = g_{m4}(r_{o2} || r_{o4})$

◇ Source follower Gain (current gain)
Q7 A + B

$A_{V(SF)} \approx 1$ (page 70, lab manual)

Open loop Gain: product of all gains

$A_{V(open)} = A_{V(diff\ amp)} \times A_{V(CSA)} \times \underbrace{A_{(SF)}}_{\approx 1}$

$A_{V(open)} = A_{V(diff\ amp)} \times A_{V(CSA)}$

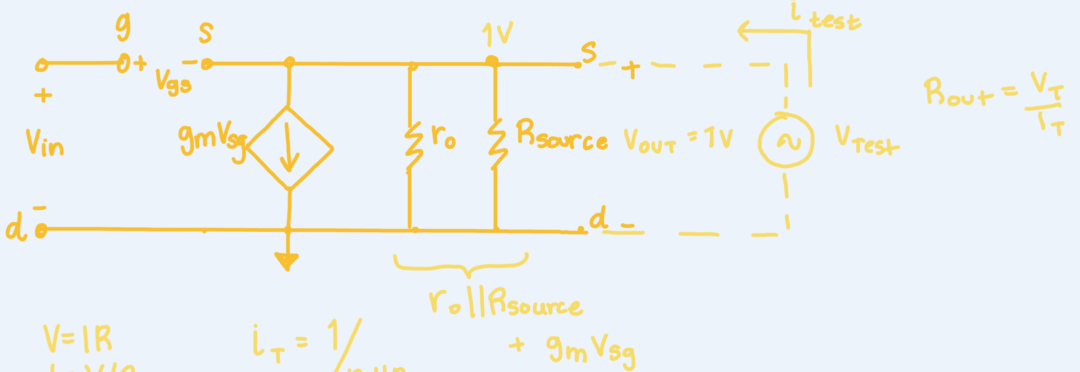
$\boxed{A_{V(OL)} = (g_{m6}(r_{o6} || r_{o9})) \times (g_{m4}(r_{o2} || r_{o4}))}$

3. Estimate output resistance of CD output amp in 6.3

$V_{out} = 0V$

common drain = source follower

Source follower:



$R_{out} = \frac{V_T}{I_T}$

$V = IR$
$I = V/R$

$i_T = 1/r_o || R_{source} + g_m V_{sg}$

common drain: $R_{out} = 1/g_m \, || \, r_o \, || \, R_{source}$

↓

$R_{out} \approx 1/g_m$ (6.1)

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$g_m = \sqrt{2K \frac{W}{L} I_D}$

$I_D = 200\mu A$ (task 6.5.1)

$\frac{W}{L} = \frac{138}{7.8}$

$K = 11\mu A$

$g_m = 8.8$ mS

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$r_o = \frac{1}{\lambda_p I_D}$

$\lambda_p = .008$
$I_D = 200\mu A$

$r_o = 625\ \Omega$

$= \frac{1}{8.8 \times 10^{-3}} \,||\, 625 \,||\, 10K$

$= \left(8.8 \times 10^{-3} + \frac{1}{625} + \frac{1}{10K}\right)^{-1}$

$\boxed{r_o = 95.2\Omega}$

Fig 6.5 : $R_{source} = 10k\Omega$