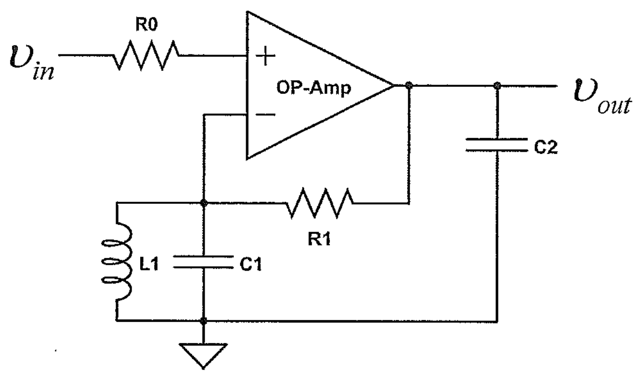
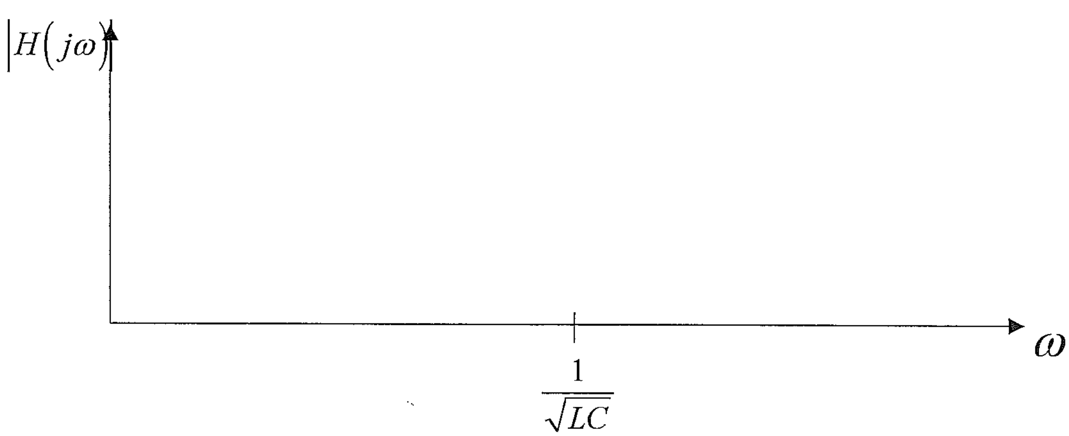
1. For the circuit shown below, find:

A. [13 points] its small signal transfer function $H(j\omega) = \frac{v_{out}}{v_{in}}$,

B. [12 points] and plot |H(jω)| as a function of frequencies. Sketch just a rough shape of the curve, and clearly mark the value of |H(jω)| when $\omega = \frac{1}{\sqrt{LC}}$. For |H(jω)|, use [V/V] as its unit, not dB.

For both parts A and B, assume the OP-Amp is ideal.



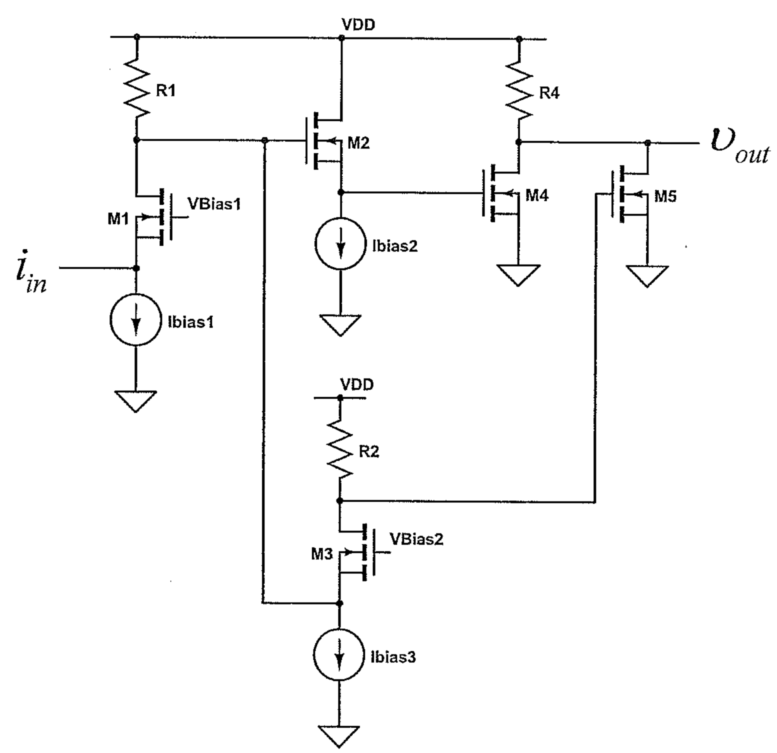


2. [25 points] For the circuit shown below, find its low-frequency small-signal output voltage υ_{out} as a function of input current i_{in}. [Note: The input is a small-signal current, not voltage.]

Assume:

- All transistors are biased in saturation.
- No parasitic capacitance exists.
- All bias current and voltage sources are ideal.
- $r_{o1} = r_{o2} = r_{o3} = r_{o4} = r_{o5} = \infty$
- $g_{m1} = g_{m2} = g_{m3} = g_{m4} = g_{m5} = g_m$
- $R_1 = R_2 = R_4 = \dfrac{1}{g_m}$

(M1, M2, M3, M4 and M5 are n-channel MOSFETs.)



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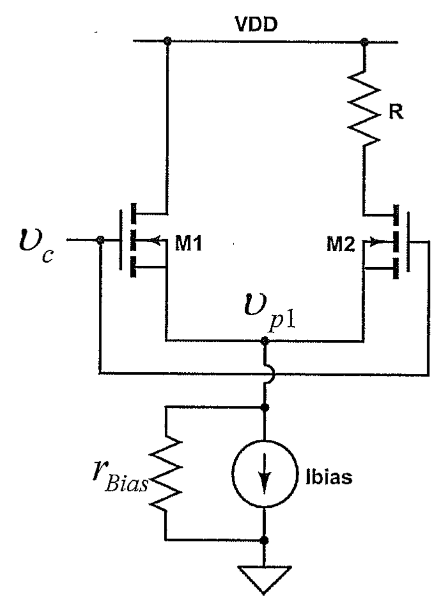
3. For the circuit shown below, assume:
   - All transistors are biased in saturation.
   - No parasitic capacitance exists.
   - $r_{o1} = r_{o2} = \infty$
   - $r_{Bias} \neq \infty$
   - $g_{m1} = g_{m2} = g_m$
   - Ibias is ideal.

   (M1 and M2 are n-channel MOSFETs.)

   [13 points] Find the small-signal voltage υ_{p1} when a common mode small signal υ_c is applied.



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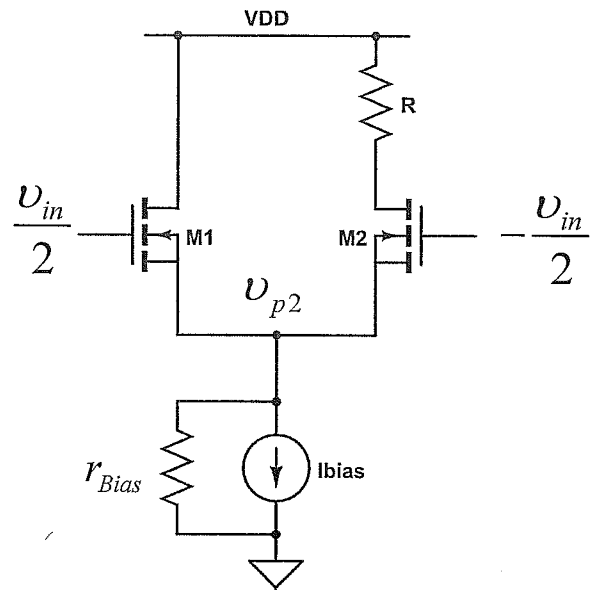
[12 points] Now a differential small-signal input υ_{in} is applied to the same circuit. Find υ_{p2}.



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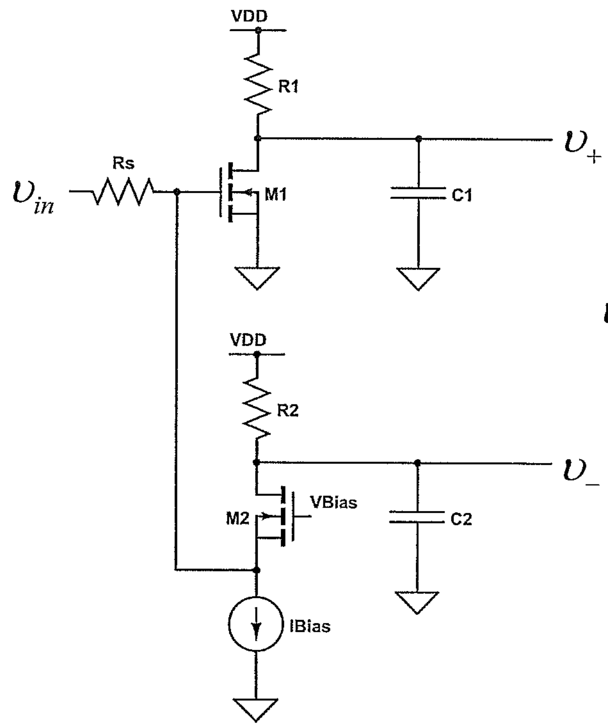
4. [25 points] For the circuit shown below, find $H(j\omega) = \frac{v_{out}}{v_{in}}$.

Use one pole per one node approach.
Don't find zero(s).

Assume:

- All transistors are biased in saturation.
- All bias current and voltage sources are ideal.
- $r_{o1} = r_{o2} = \infty$
- $g_{m1} = g_{m2} = g_m$
- $R_1 = R_2 = R$
- $C_1 = C_2 = C_L$



$v_{out} = v_+ - v_-$

For M1 and M2, use the small signal model shown below ($C_{gs1} = C_{gs2} = C_{gs}$):