

Massachusetts Institute of Technology
Department of Electrical Engineering and Computer Science

6.776 High Speed Communication Circuits

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Mid-Term Exam

April 7, 2005

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Name _____

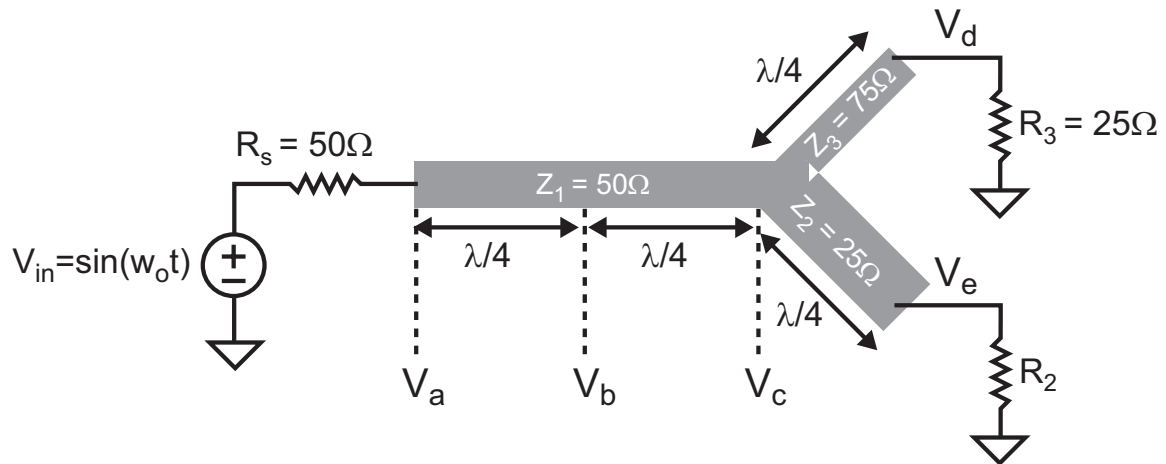
Problem 1 _____ (24 points)

Problem 2 _____ (40 points)

Problem 3 _____ (36 points)

Total _____ (100 points)

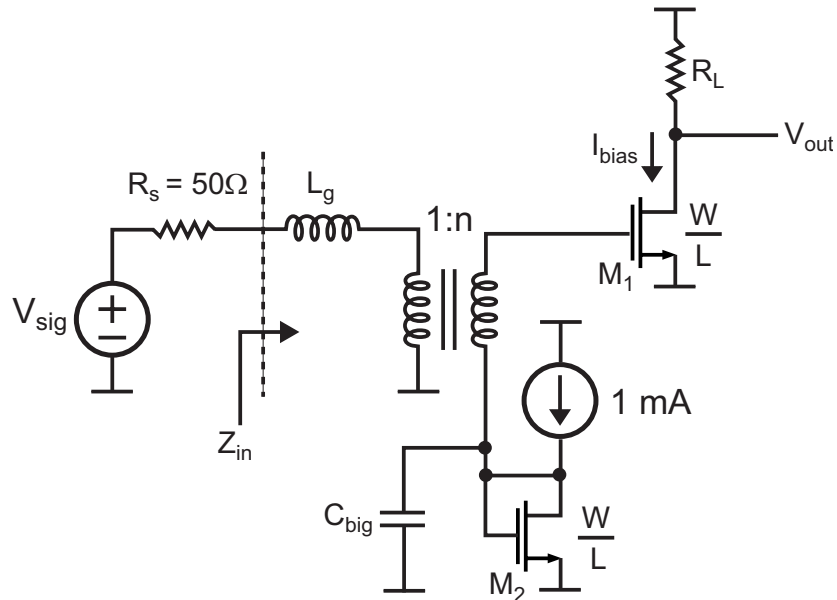
1. (24 points) Consider a set of transmission line segments that are joined in a T-section as shown below. For all parts in this problem assume that all energy traveling down the lines is confined to the transmission line dielectric (i.e., ignore the impact of fringe fields) and travels in the TEM mode.



- a. (8 points) Given $R_2 = 0$ (i.e., a short circuit), compute V_a , V_b , V_c , V_d , and V_e .

b. (8 points) Given $R_2 = \text{infinity}$ (i.e. an open circuit), compute V_a , V_b , V_c , V_d , and V_e .

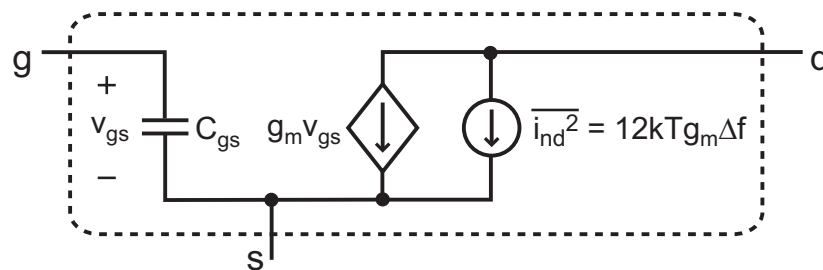
2. (40 points) Consider the use of a transformer within a low noise amplifier as shown below:



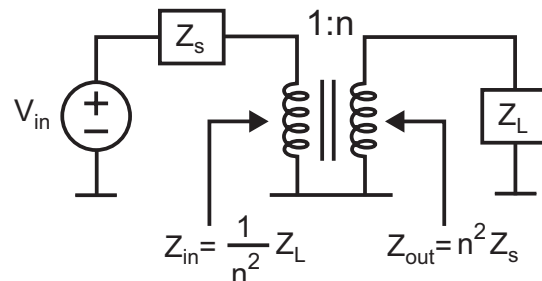
For all questions within this problem, assume that all transistors are in the saturation region and are modeled with the small signal model shown below. Further, assume all transistors have small-signal parameters of

$$g_m = 1/(1\text{k}\Omega), C_{gs} = 100 \text{ fF}, kT = 4.14\text{e-}21$$

and also assume that gate noise is zero, (i.e., $\delta = 0$) for all transistors.



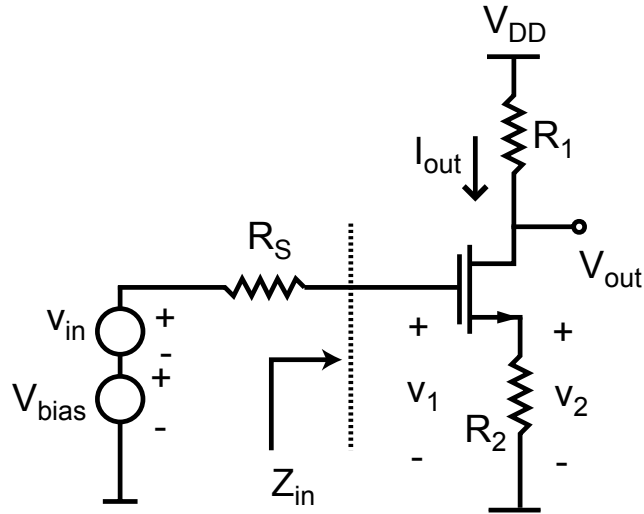
Also note that the ideal transformer used in the above circuit transforms complex impedances as shown below:



- a. (10 points) Assume that V_{sig} is a sine wave at frequency ω_o , where ω_o is high enough that C_{big} is well approximated as a short circuit. Assuming that L_g is tuned such that $Z_{in} = 0$ Ohms at frequency ω_o , compute the gain from V_{sig} to V_{out} as a function of the transformer turns ratio, n . For high gain, should n be high or low?

b(30 points) Under the same assumptions as (a), compute the noise figure of the amplifier as a function of the transformer turns ratio, n . Ignore the influence of R_L in your calculation. For low noise figure, should n be high or low?

3. (36 points) Consider the use of a source degenerated amplifier shown in the following figure. Ignore all other device parasitic capacitances except C_{gd} and C_{gs} of M_1 . Also, ignore the back-gate effect and finite r_o of M_1 .

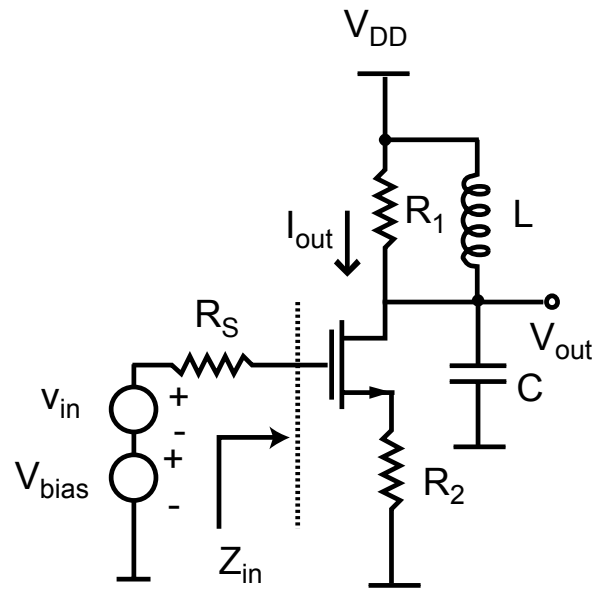


- a (4 points) compute the low frequency small-signal gain $A=v_{out}/v_{in}$ at low frequencies. **(ignore all capacitances in the circuit for this part)** .

b. (6 points) Derive the incremental gain $A_1 = v_{\text{out}}/v_1$ and $A_2 = v_2/v_1$ at low frequencies **(ignore all capacitances in the circuit for this part)**.

c (6 points) Find Z_{in} using the results of part b) and Miller effect from C_{gs} and C_{gd} . Assume $\omega \ll 1/(C_{gd}R_1)$.

d (10 points) Find the low frequency noise factor of the above amplifier. Ignore the noise contribution from R_1 in this analysis.



e (10 points) The circuit is modified as shown above in order to tune out the load capacitor C . Derive Z_{in} at a frequency $\Delta\omega$ below the resonant frequency of the LC tank circuit. $\Delta\omega$ is a small deviation from the center frequency.