EE618 (Zele)

CMOS Analog VLSI Design : Homework - 4 (30 - Marks)

Submission Deadline : 30th Sept 2019 11:55 AM

- All problems are based on Cadence simulations. Use Vdd = 1.8 V
- The submission must contain appropriate plots labelled clearly.
- The submission must contain the theoretical calculations wherever it is applicable.
- Submission must be in ***Teamname_Rollnumber_Yourname_Assignment4.pdf*** format.
- Submissions after deadline with not be accepted under any circumstances.
- All MOSFET models should be used from SCL 180 nm library.
- MOSFETS in schematics must be annotated with all required parameters. Ex: Width, Length, Fingers, Multipliers.
- Report all values preferably in tabular format wherever it is appropriate.

Question 1

Understanding the flicker and thermal noise of MOSFETs

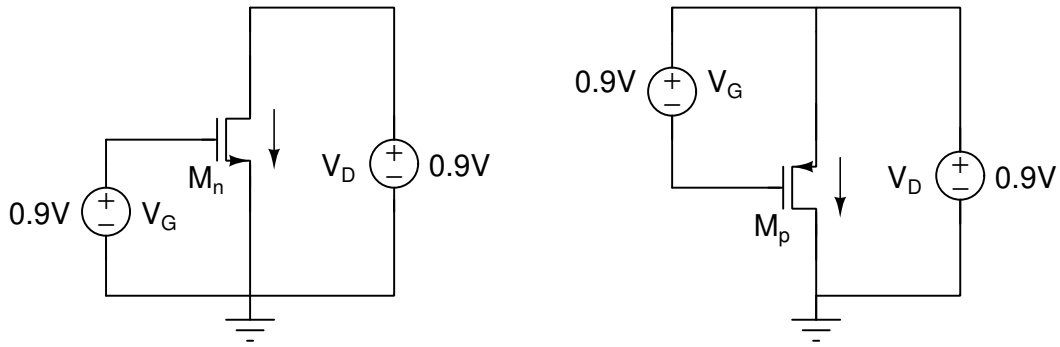

Figure 1

Consider the following cases:

- **Case A for Fig. 1.a)**: (W/L) = (2.2μm/0.18μm) x 5 multipliers
- **Case B for Fig. 1.a)**: (W/L) = (2.2μm/0.36μm) x 10 multipliers
- **Case C for Fig. 1.b)**: (W/L) = (2.2μm/0.18μm) x 5 multipliers

a) For all the above cases, Overlay the plots of the noise current flowing through the transistor in the frequency range of 1Hz to 10GHz. The X-axis (frequency with 100 points/decade) and Y-axis (noise current magnitude in A/$\sqrt{Hz}$) should be in logarithmic scale. [3 Marks]

b) Report the approximate corner frequency (f_c). (You may consider the knee region of the curve as f_c) [3 Marks]

	Corner frequency (f_c)
Case A	
Case B	
Case C	

Which of the above cases has the lowest thermal noise and why? Which case would you prefer to design an OTA with low flicker noise and why? [2 Marks]

Question 2

Understanding the noise in amplifiers

A. For the CS amplifier shown in Fig. 2, perform the noise analysis in the frequency range of 1Hz to 10GHz for the following cases:

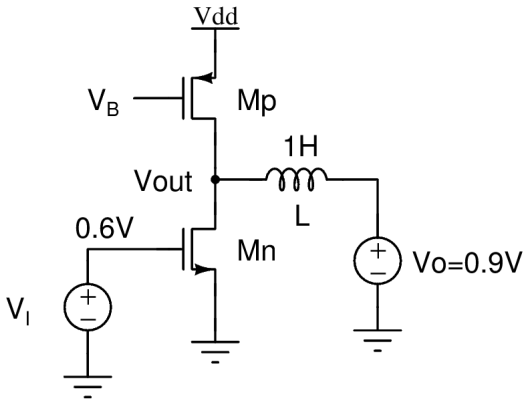

Figure 2: CS amplifier with PMOS current source load

- **Case A**: (W/L)n = (2μm/0.18μm) x 4 , (W/L)p = (2μm/0.18μm) x 2, V_b = 0.9V
- **Case B**: (W/L)n = (2μm/0.18μm) x 2, (W/L)p = (2μm/0.18μm) x 9, V_b = 1.2V

Note: The inductor is added to provide a DC bias at the output node. Large inductance offers low impedance near DC.

a). Report the noise contributions at 200MHz. [3 Marks]

Spot Noise @ 200 MHz	**Case A (in V/$\sqrt{Hz}$)**	**Case B (in V/$\sqrt{Hz}$)**
Total Noise @ output due to Mn		
Total Noise @ output due to Mp		
Input referred noise		

Which case has the low input referred noise voltage? Justify your answer with appropriate expressions for input referred noise of the CS amplifier shown in Fig. 2. [3 Marks]

B. For the following cascode amplifier, perform the noise analysis in the frequency range of 1Hz to 10GHz and tabulate the following. [4 Marks]

Given, $(W/L)_1$ = (2μm/0.18μm) x 3 , $(W/L)_2$ = (2μm/0.18μm) x 3

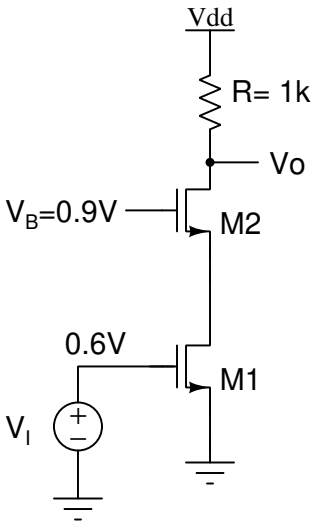

Figure 3: Cascode amplifier

Spot Noise @ 200MHz	Noise (in V/$\sqrt{Hz}$)	% of total
Total Noise @ output due to M1		
Total Noise @ output due to M2		
Total Noise @ output due to R		
Input referred noise		

What is the effect of noise of M2 on the input referred noise? Justify your answer with the appropriate expressions for the noise of a cascode amplifier. [3 Marks]

C. Perform the noise analysis for the following differential amplifier in the frequency range of 1Hz to 10GHz.

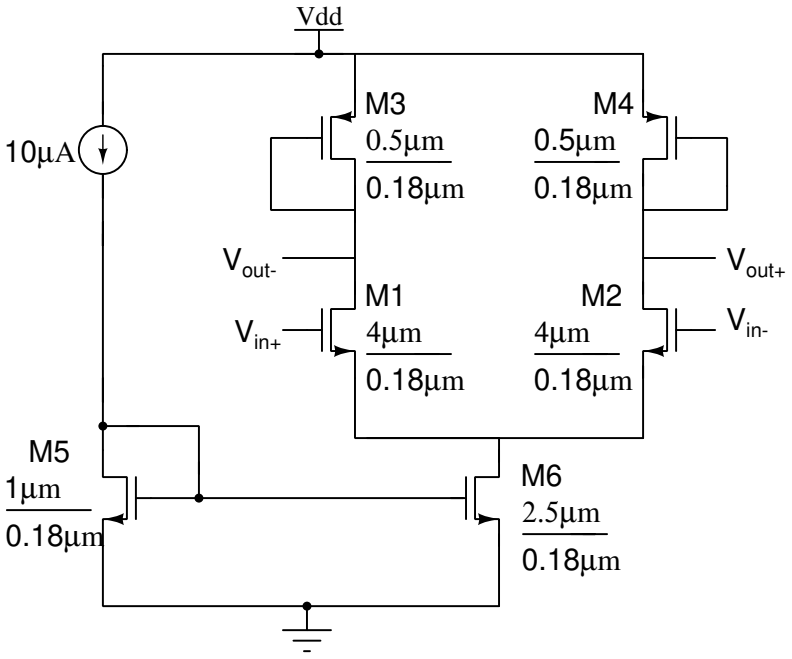

Figure 4: Differential Amplifier

Note: Apply an input DC Common Mode voltage of 1.1 V without any AC input. Use the following format for tabulation for C.a) and C.b).

Transistor	Type	Noise (in V^2)	% of total
M1	Flicker		
M1	Thermal		
.			
.			
M6	Flicker		
M6	Thermal		
Total Noise			
Input referred noise			

a) Tabulate the noise summary by measuring the noise values at the output in a single ended manner (i.e. at V_{out+} w.r.t ground) integrated in bandwidth of interest from 10kHz to 10MHz. Report the major contributor to output referred noise in this case? [4 Marks]

b) Tabulate the noise summary by measuring the noise values at the output in a differential manner (i.e. at V_{out+} - V_{out-}) integrated in bandwidth of interest from 10kHz to 10MHz. Report the major contributor to to output referred noise in this case? [4 Marks]

What is the contribution of the tail current source to the total output noise? Explain your observation. [1 Mark]

Let's make some noise ☺