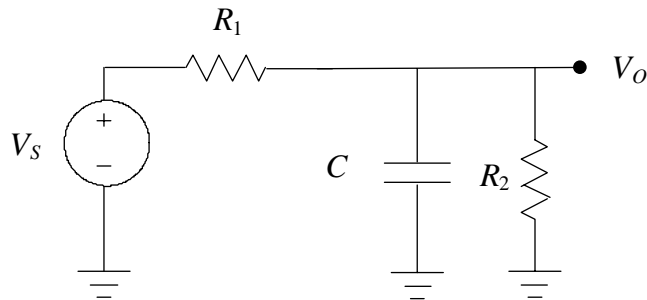


CAD Assignment # 1

General Instructions:

- Use markers in the waveform window to get accurate intercept data
- Use the various features in the waveform editor to label your axes, units, plot titles and trim the axes
- Specify units for all the answers
- $W_{\min} = 1.5\mu\text{m}$ and $L_{\min} = 0.6\mu\text{m}$
- Return this sheet with the answers filled up, along with the schematics and waveforms

Problem 1 (15 points):



Build the above RC circuit in the Virtuoso Schematic Editor. $R_1 = 10\text{k}\Omega$, $R_2 = 1\text{k}\Omega$, $C = 1\mu\text{F}$. Carry out the following analyses using Spectre:

1. Transient analysis with a square wave input (100 Hz, 0 – 5 V)
 - Observed rise time of the output (10%-90%, i.e., $0.1V_{\max} - 0.9V_{\max}$): _____
 - Calculated rise time of the output (10% - 90%): _____
 - Observed fall time of the output (90%-10%, i.e., $0.9V_{\max} - 0.1V_{\max}$): _____
 - Calculated fall time of the output (90% - 10%): _____
2. DC sweep of the input from 0 to 5 V
 - What is the observed gain of the circuit in this condition? _____
 - What is the calculated gain of the circuit in this condition? _____
3. Bode plot showing both the magnitude and phase plots (your frequency axis must end 2 or 3 decades on either side of the cutoff frequency)
 - Observed Cutoff frequency (i.e., 3 dB below the flat-band gain) : _____
 - Calculated Cutoff frequency: _____

You need to turn in the following hardcopies:

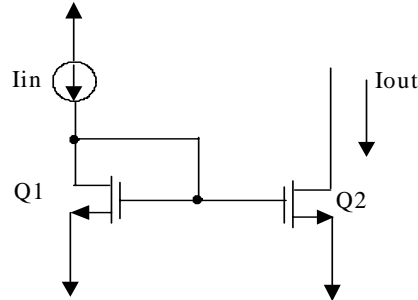
- Schematic of the RC circuit in Virtuoso Schematic Editor
- Input and Output waveforms for the transient analysis showing approximately two periods of the input waveform
- DC sweep of Input vs. Output

- Bode plot (magnitude and phase) showing cutoff frequency

(You should have most of the calculated values from the last homework. All the help for simulation is available in Tutorial 1.)

For the next 2 problems, you might want to go through the operation of basic current mirrors (Section 3.1, Johns & Martin).

Problem 2 (25 points):



The above figure shows the circuit of a simple nMOS current mirror. $I_{in} = 10\mu A$. Aspect ratio of Q1 is set to W_{min} / L_{min} ($W_{min} = 1.5\mu m$ and $L_{min} = 0.6\mu m$).

1. Set W/L of Q2 = W_{min} / L_{min}
 - Perform a transient analysis for $10\mu s$ with V_{DS} of Q2 set to 1.2 V. Measure I_{out}

(a) $I_{out} =$ _____
 - Perform a DC sweep of V_{DS} of Q2 from 0 to 5 V. Measure the Early voltage V_A . (Use markers and intercept data to find the equation of the line and then find the x-intercept)

(b) $V_A =$ _____
2. Find I_{out} by performing a transient simulation of $10\mu s$ with W of Q2 = $10(W_{min})$ for the first time and then Q2 = $100(W_{min})$, with $L = L_{min}$.

(c) I_{out} for $W = 10(W_{min}) =$ _____ (d) I_{out} for $W = 100(W_{min}) =$ _____

How do currents in results (a) and (c) compare? Does the current increase by a factor of 10 each time? Justify your comparison.

How do currents in results (c) and (d) compare? Does the current increase by a factor of 10? Justify your comparison.

3. Placing 'M' transistors of aspect ratio 'W/L' is equivalent to a single transistor of size M times W/L. 'M' is called the multiplier, and is a shortcut we can use in Spectre to create multiple equivalent transistors connected in parallel. Now, determine Iout by performing a transient simulation of 10μs with W/L of Q2 set to W_{min} / L_{min} , but set the multiplier factor 'M' in the properties of Q2 to 10 and 100 respectively.

(e) Iout for M = 10 = _____ (f) Iout for M = 100 = _____

How do currents in results (a) and (e) compare? Does the current increase by a factor of 10? Justify your comparison.

4. Set W of Q2 = 10(W_{min}) and L of Q2 = 10(L_{min}). Note W/L ratio is same as W_{min} / L_{min} . Perform a DC sweep of V_{DS} of Q2 from 0 to 5 V. Measure the Early voltage V_A . (Use markers and intercept data to find the equation of the line and then find the x-intercept)

(g) V_A = _____

How do the Early voltages in results (b) and (g) compare? Justify your comparison.

You need to turn in the following hardcopies: (Ensure your plots are labeled)

- Schematic of the nMOS current mirror circuit in Virtuoso Schematic Editor
- Iin and Iout for all the transient analysis
- DC sweep of V_{DS} Vs Iout for all the DC analysis, mentioning the Early voltage.

(Help for simulation is available in help-file 1)

Problem 3 (10 points):

Design a pMOS current mirror circuit with Iin = 10μA. Aspect ratios of Q1 and Q2 are set to W_{min} / L_{min} .

- Perform a transient analysis for 10μs with $|V_{DS}|$ of Q2 set to 1.2 V. Measure Iout

(a) Iout = _____

- Perform a DC sweep of $|V_{DS}|$ of Q2 from 0 to 5 V. Measure the Early voltage V_A . (Use markers and intercept data to find the equation of the line and then find the x-intercept)

(b) V_A = _____

You need to turn in the following hardcopies:

- Schematic of the pMOS current mirror circuit in Virtuoso Schematic Editor
- Iin and Iout for the transient analysis
- DC sweep of V_{DS} Vs Iout for the DC analysis, mentioning the Early voltage.