25 Spring ECEN 610: Mixed-Signal Interfaces

Lab3: Analysis and Simulation of switched Gm-C Filters

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Section:601

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1. Consider the following circuit, where N=8 and the frequency of the clocks is 2.4 GHz and Cs=15.925 pF. The capacitors are charged in a cyclic fashion by the input current iRF. Similarly, the voltage stored in the capacitors Cs is read cyclically at the end of each consecutive N cycles. The output of the circuit is the concatenation of the cyclic readings of the voltages. Consider the following 2 cases:

a) The capacitors are discharged after each read out operation, i.e. the charge of the capacitors is zero at the beginning of the integration of every N cycles.

b) The capacitors are never discharged.

In both cases find the filter transfer function H(f)=Vo(f)/iRF(f) where Vo(f) is the capacitor voltage. Please use a mathematical description of how the transfer function is found and then use Python to plot the transfer functions.

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According to model as moving average, the filter has a sinc frequency response with null positions at k\*f0/N= k\*300M where k=1,2,3… (clear o discharge at every T\*n period, in freq gain=0)

**Case (a):** Since the integrator resets (dumping the accumulated charge) at each interval, it only averages the input over that short time period. For very low-frequency signals (even DC), the output is limited to this brief average and then reset, resulting in a lower and flatter response.

**Case (b):** The integrator never resets, so the capacitor continuously accumulates charge. This continuous integration allows the output for very low-frequency signals (and DC) to build up over time, yielding a higher response at low frequencies compared to case (a).

1. Now consider the addition of a “history” capacitor CH=15.425 pF and a “rotating” capacitor CR=0.5 pF.

a.) Explain the effect of adding the capacitor CH in the transfer function that was calculated in problem 1.

b.) Find the new transfer function and plot it using Python.

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1. Consider the following circuit. This is just an extension of the previous circuit where the cyclic operation is extended to 8 capacitors. As in the previous circuit, every capacitor also stores N=8 cycles of the input switched current. The output voltage is defined as the voltage resulting from the physical connection of the bank of 4 capacitors enclosed by the rectangle in the figure. This read out operation is also made in a cyclic fashion between the 2 bank of capacitors. Assume ideal transistors and an ideal transconductance gm. Find a mathematical expression for the transfer function and plot in Python for the following 2 situations.

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1. The 4 capacitors are discharged after their connection and read out operation, i.e. the charge of the capacitors is zero at the beginning of the integration of every N cycles.

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1. The capacitors are never discharged.

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1. The capacitors are discharged but they have different sizes, i.e. CR1, CR2, CR3, CR4.

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* Appendix

Q1

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Q1\_check

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Q2

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Q3-a

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Q3-b

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Q3-c

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