EE 591L – Neuromorphic Analog VLSI
Project 5 – G_m-C Circuits and Filters

Objective
To become familiar with first- and second-order G_m-C circuits and filters. Primarily, this project will focus on the follower-integrator (first-order circuit) and the classic second-order section.

Capacitance Values
For all capacitors in this project, use a value of 1pF.

Part 1 – Follower-Integrator Step Response
Using the wide-range OTA subcircuit you developed for Project 4, simulate a step response for a first-order follower-integrator, as described in class, for two conditions.

- Small input step voltage
- Large input step voltage

In each case, your step voltage should start at one DC value, step up to another DC value, and then step back down to the original DC value. Your output waveform should clearly show the response of your circuit to an upward- and downward-going step input. Make sure that the length of the step (time duration) is long enough to capture the full exponential rise/decay.

Simulate a step response of the follower-integrator for two different bias voltages using a small input voltage step (you must determine what constitutes a small input step). Alternatively, you may use a current mirror to establish the current flowing in the tail of the OTA; use two different bias currents. Make sure the bias current is a subthreshold current.

- Determine the time constant for both cases
- Determine the rise time (time duration to go from 10% to 90% of the final value)

Simulate a step response of the follower-integrator for two different bias voltages/currents (the same as for the previous part) using a large input voltage step.

- Determine the slew rate of the follower-integrator (I/C)
- Approximate the linear range of the follower-integrator by finding the dividing line between the linear portion of the response and the exponential portion of the response
- Is the time constant the same as it was with a small input voltage step?

Part 2 – Follower-Integrator Frequency Response
Using the same bias voltages/currents as in Part 1, perform a frequency response (AC sweep) of the follower-integrator.

- Determine the corner frequency for both biases
- Does the time constant agree with the measured time constants from Part 1?

Part 3 – Classic SOS Step Response
Using the wide-range OTA subcircuit you developed for Project 4, create a SPICE deck for a classic second-order section, as described in class.

Simulate a time-domain response to a small step input. Using only one bias for the time constant, vary the bias controlling the amount of resonance (or *Q*) for two different values of *Q*.

Simulate both an upward-going and downward-going step, and make sure that the circuit response has significantly died out before making the next step.

- Extract the time constant for both cases
- How do the two values of the time constant compare?
- Approximate the quality factor (*Q*)
- Experimentally, how far can you increase the bias voltage/current controlling the quality factor before the circuit goes unstable?

Part 4 – Classic SOS Frequency Response

Using the same bias voltages/currents as in Part 3, perform a frequency response (AC sweep) of the classic SOS.

- Determine the corner frequency
- Does this corner frequency agree with the time constant from Part 3?
- Approximate the value of *Q*
- How does this value of *Q* compare to the value found in Part 3?