Homework Assignment #5 ELEC 5760/6760 Due: Wednesday 9/28/22

1) A MEMS device consists of a proof mass attached to a frame with a suspension system. The bottom of the proof mass is 1 mm by 1 mm in size and serves as an electrode. Another electrode of the same size is located 2 μm beneath it. If the proof mass can move up and down ±1 μm from its nominal distance to the bottom electrodes, calculate the nominal, maximum and minimum capacitance between the two electrodes. Assume that the device is in a vacuum.

2) A certain MEMS capacitance has a rest (i.e. nominal) value of 3 pF, a minimum value of 2 pF and a maximum value of 5 pF. Place it in a charge amplifier circuit that has an input voltage of 10 V and a feedback capacitor (C2) of 10 pF. Calculate the amplifier output voltage (at the end of the $\phi 2$ cycle) for the nominal, minimum and maximum capacitance values.

3) For the MEMS capacitance in (2) place it in a 5 V CMOS relaxation oscillator circuit with both resistors being 100 kΩ. What is the output frequency for C_{min}, C_{nom} and C_{max}?

4) If two MEMS capacitances from (2) are placed in a capacitive AC voltage divider to realize a differential capacitive sensor configuration, with the input voltage having an amplitude of 10 V, what is the output voltage amplitude for each case?

5) If the MEMS capacitance from (2) is placed in a switched-capacitor circuit that is switched at 250 kHz, what is the value of the equivalent resistance for the nominal, minimum and maximum capacitance values?

6) If the MEMS device in (2) is placed in an RC phase delay circuit, where R = 250 kΩ, what is the phase delay in μs for the nominal, minimum and maximum capacitance values?

7) Your resistive sensor measures a conductance of 100 μS in an aqueous solution at 10°C. If your sensor's cell constant is 10 m, what the EC at 25°C, using a temperature compensation factor of 0.02 /°C?