## EE 435 Assignment 9 Spring 2025 Due Monday April 28

**Problem 1** Consider the feedback amplifier shown designed for a gain with feedback of -4. Assume the operational amplifier is ideal. Consider unary resistor cells of length 10µm and width 2µm designed in a process with Pelgrom parameter  $A_{\rho}=0.05\mu m$  and sheet resistance of  $R_{\Box} = 1K\Omega/\Box$ . Assume all amplifiers that have a gain that deviates more than  $\pm 1\%$  from the nominal value are rejects. Assume the only no ideality in the resistors is the local random variations that have variance

$$\sigma_{\frac{R}{R_N}} = \frac{A_{\rho}}{\sqrt{WL}}$$

where  $R_N$  is the nominal value of the unary cell, W is the width of the resistor in the unary cell and L is the length of the resistor in the unary cell.

- a) Determine the yield of this amplifier if  $R_2$  is made by connecting 4 unary cells in series and  $R_1$  is comprised of a single unary cell.
- b) Repeat part a) of R<sub>2</sub> is made by placing 2 unary cells in series and R<sub>1</sub> is comprised of two unary cells connected in parallel.



**Problem 2** Consider the current steering DAC shown below where everything is ideal except for the resistors. Assume the resistor on the left is made from a unary cell. The resistor R/2 is made by placing two unary cells in parallel, the resistor R/4 is made by placing 4 unary cells in parallel and so on with the right-most resistor formed by placing  $2^{n-1}$  unary cells in parallel. Assume the switches, the Op Amp, and the feedback resistor  $R_F$  are ideal and the only nonideality in the resistors is the local random variations that have variance

$$\sigma_{\frac{R}{R_N}} = \frac{A_{\rho}}{\sqrt{WL}}$$

where  $R_N$  is the nominal resistance value of the unary cell, W is the width of the unary cell, L is the length of the unary cell, and Ap is the Pelgrom parameter that characterizes the mismatch due to local random variations.



**Part 1** Determine the yield of this DAC if the ENOB based upon the INL must be at most 1 LSB, n=8, WL=5 $\mu$ m<sup>2</sup>, and  $A_{\rho}=0.05\mu$ m.

**Part 2** (Extra Credit) Determine the area of the unary cell required to obtain a 99% yield if the ENOB based upon the INL must be at most 1 LSB, n=8, and  $A_{\rho}$ =0.05µm.