EE 508
Homework 3
Fall 2022
Due Monday October 10

This assignment will focus on statistical analysis and yield calculation. For convenience, emphasis will be placed on calculating the yield of a finite gain amplifier but the same issues will be applicable to filter structures as well. Assume all resistors are made from a thin film with sheet resistance of 1K Ω/□ and the resistors are from a process with $\sigma_{\frac{R_{PROC}}{R_{NOM}}} = 0.2$ and with Pelgrom matching parameter of A_ρ = 0.025µm. Neglect any gradient effects in the process.

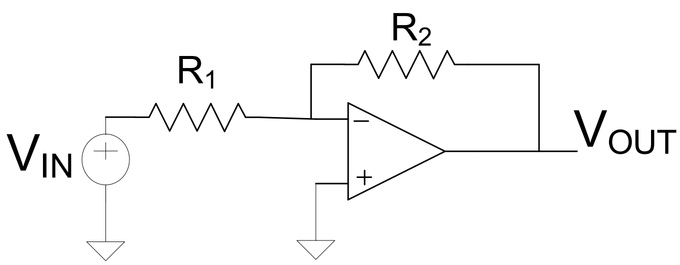


Fig. 1 Basic Single Stage Inverting Amplifier

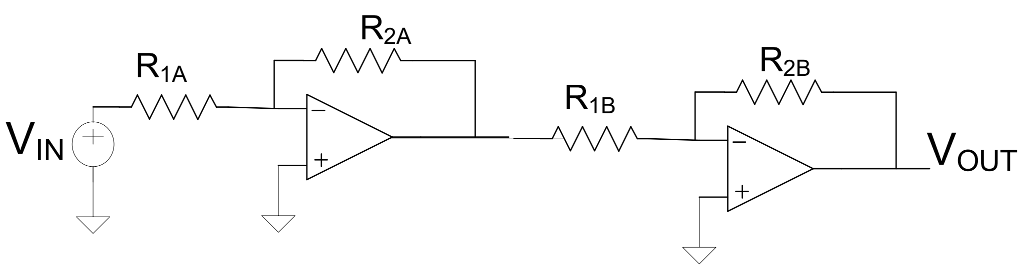
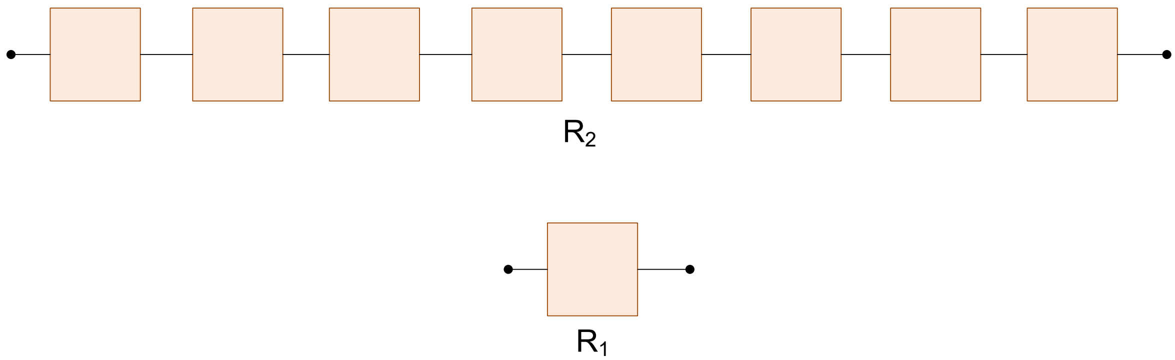


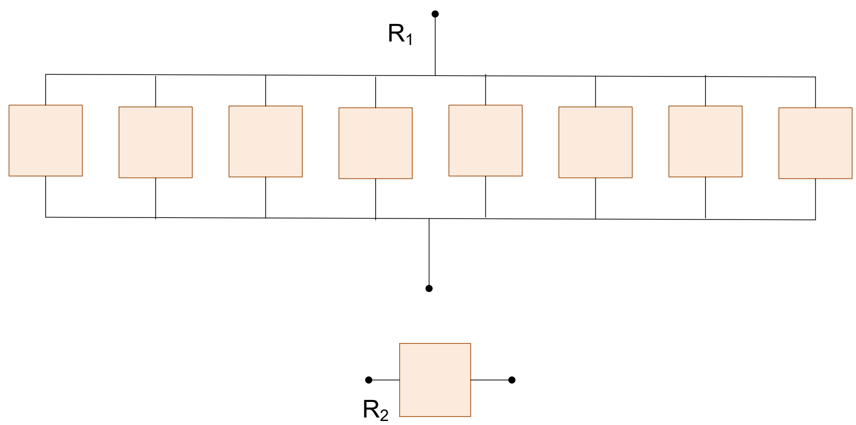
Fig. 2 Basic Two-State Amplifier

Problem 1.

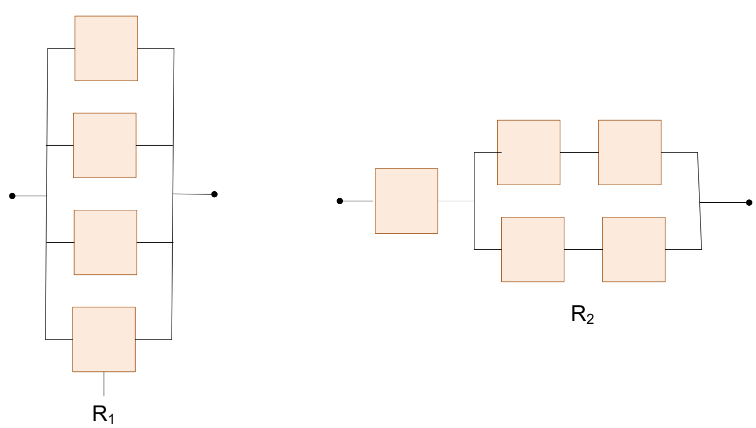
Assume a design requirement of an amplifier using the basic single-stage structure of Fig. 1 with a gain magnitude of 8 that must be accurate to within 1%. Assume R_2 is configured by the series connection of 8 unary cells and R_1 is comprised of a single unary cell where each of the unary cells has an area of 10um^2. These resistors structures are depicted below. Analytically determine the yield of this amplifier. Neglect any yield loss associated with hard faults.



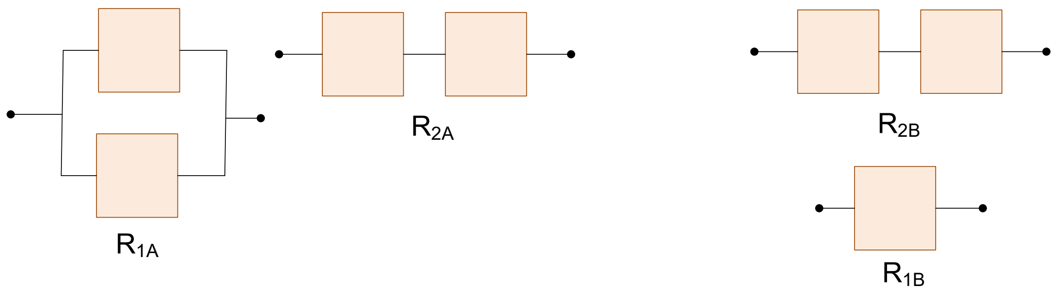
Problem 2 Repeat problem 1 if R_1 and R_2 are configured as depicted below. Assume the unary cells are the same size as those used in Problem 1.



Problem 3 Repeat Problem 1 if R_1 and R_2 are as shown below. Assume the unary cells are the same size as those used in Problem 1.

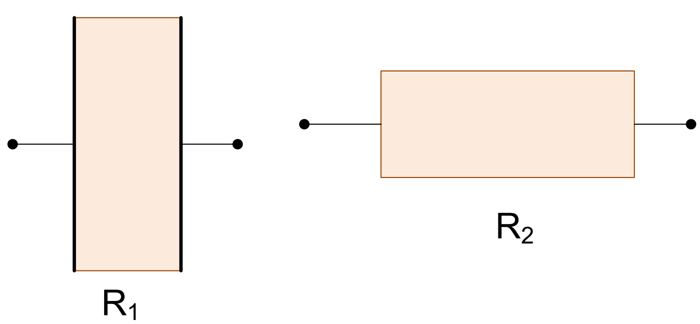


Problem 4 Repeat Problem 1 if the two-stage amplifier of Fig. 2 is used. The resistors R_{1A} , R_{2A} , R_{1B}, and R_{2B} are as shown below. Assume the unary cells each have an area of 13um^2 (note that the total resistor area is approximately the same as that in the previous 3 problems).



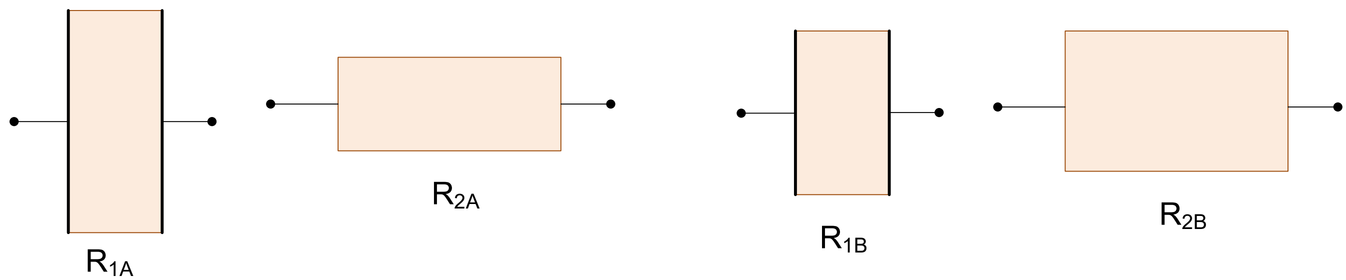
Problem 5 You should have noticed in the previous problems that the yield varies significantly based upon how the area is allocated between the resistors in the amplifier. Quantitatively compare the previous amplifiers and draw conclusions about how the area should be allocated to optimize yield in the feedback amplifiers.

Problem 6 Size the resistors R_1 and R_2 for optimizing the yield of the basic feedback amplifier of Fig. 1 if the amplifier is to have a gain magnitude of 8 and the total resistance area is 90 um^2 . Compare the results of the optimum design with those that were considered in Problems 1-4. For practical reasons, the resistors associated with optimal area allocation in the problem would likely be broken into a number of unary cells before fabrication.



Problem 7 In the previous problems, it was assumed that the amplifier gain is 8. How does the yield change with the feedback amplifier gain for an optimal area assignment between R_1 and R_2?

Problem 8 Size the resistors R_{1A}, R_{2A}, R_{1B} and R_{2B} for optimizing the yield of the basic two-stage feedback amplifier of Fig. 2 if the amplifier is to have a gain magnitude of 8 and the total resistance area is 90 um^2 . In this sizing, specify how the gain should be split between the two stages in addition to how the areas of the resistors should be split between the two stages. Compare the results of the optimum design with those that were considered in Problem 6. For practical reasons, the resistors associated with optimal area allocation in the problem would likely be broken into a number of unary cells before fabrication.



Problem 9 Consider the two resistors shown below where the resistance is that between nodes A and B. In these two resistors, assume d>>W and e<<L. Compare the resistance of these two resistors and calculate $\sigma_{\frac{R_R}{R_N}}$ due to local random variations for the two resistors. Assume the bodies of the resistors are homogenous with a sheet resistance of $R_{\square}$ and neglect process variations and gradient effects.