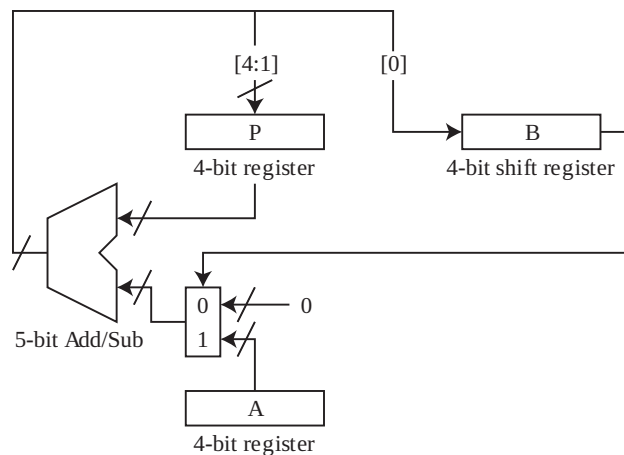


# EECS 151/251A Homework 11

Due Monday, May 8, 2023

## Problem 1: Signed Shift-and-Add Multiplication

Simulate  $-3 \times -5$  ( $A = -3, B = -5$ ) on the shift-and-add multiplier shown below. Write down the values of  $B$  and  $P$  for each cycle. Note that the inputs to the 5-bit Add/Sub are sign-extended, and it performs subtraction only in the last cycle.

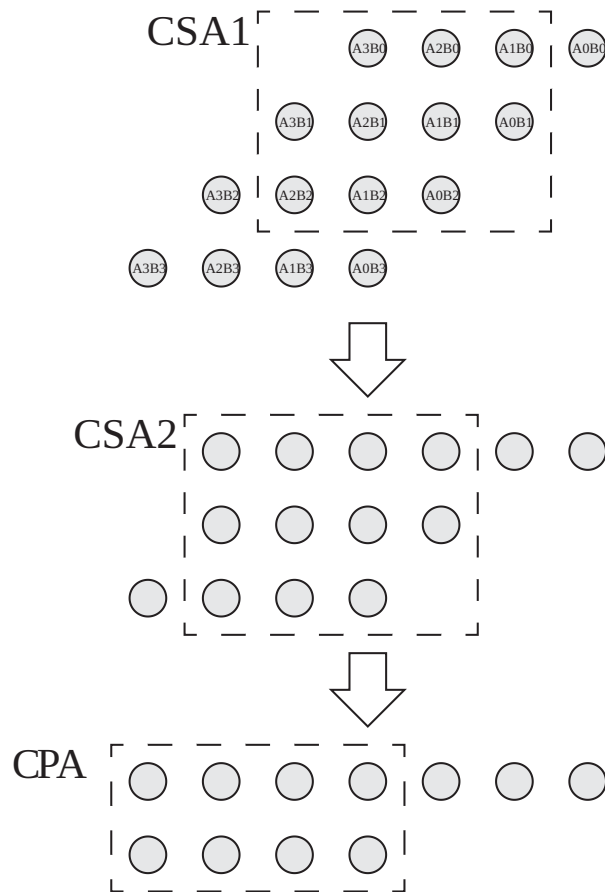


## Problem 2: Booth's Multiplication Algorithm

Walk through Booth's multiplication algorithm (radix 4) for  $8 \times -9$ , where 8 is multiplicand and  $-9$  is multiplier. Show your work.

## Problem 3: Wallace Tree

The figure below shows the Wallace tree for 4-bit unsigned multiplication. How many FAs and HAs does it use? Do not use FA when there are only 2 bits to add. Use a ripple carry adder for CPA.

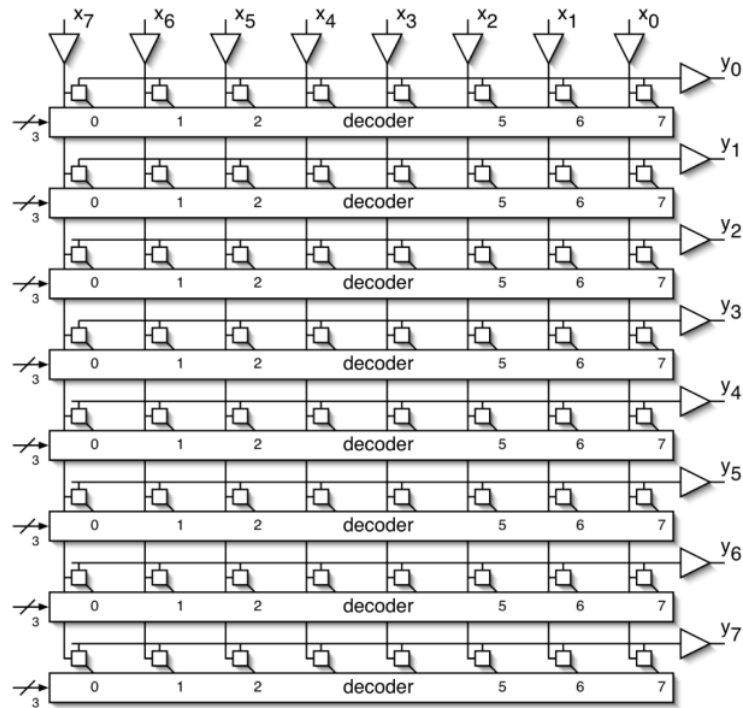


### Problem 4: Constant Coefficient Multiplication

Implement  $Z = 945X$  for input  $X$  using only 2 subtractors. *Hint: shift by a constant amount is just wiring, does not require any module.*

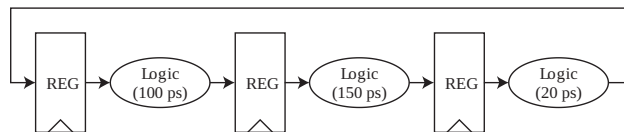
### Problem 5: Cross-bar Switch

How would you configure the decoders in the cross-bar switch below to reverse the order of bits i.e.  $y_i = x_{7-i}$  for  $i = 0, 1, \dots, 7$ ?



### Problem 6: Clock Uncertainty

Given setup time 20 ps, clock-to-q delay 10 ps, and cycle-to-cycle jitter 10 ps, what is the maximum frequency of the following circuit by adjusting the clock skew?



### Problem 7: Packaging

IC chips need to connect to power supply to be functional. If we are using solder balls (C4) each has 100 pH inductance, how many solder balls do we need to make the voltage fluctuation at most 0.1 V? Assume the maximum current spike is  $1.2 \times 10^{11}$  A/s.