

# COL215L: Digital Logic & System Design

## Lecture 12: Binary Arithmetic (Cont.)



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# 2's Complement Addition/Subtraction

- Circular
- Overflow

8 bit & 8 bit

4 bit

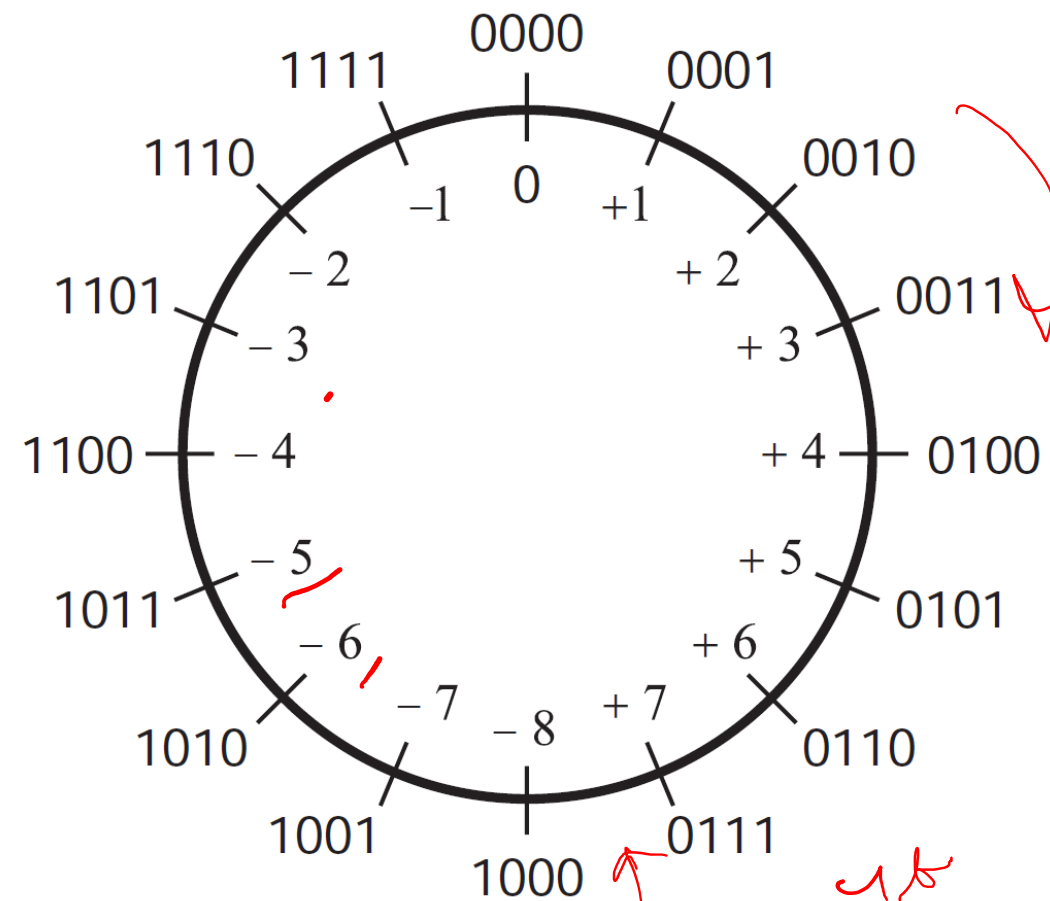
$+5 + 3 = +8$

4 bit

4 bits

Overflow counter

Sum



4 bit  
 $(\text{Carry}) \times 2^n + (\text{Sum}) = (\text{final sum})$

# Radix Representation

- Radix/base – R
- (R-1)' complement
  - $N = R^n - 1 - P$
- R' complement
  - $N = R^n - P$

1' complement

2' complement

$R = 10$

9' com -  
10' com

base  $\rightarrow 2$   
 $\downarrow$  10

74	
- 36	

  
 $74 - 36 = 74 + \underline{100} - 100 - 36$   
 $= 74 + (100 - 36) - 100$   
 $= 74 + \underline{(99 - 36) + 1} - 100$ 

99  
36

- 36  $\rightarrow$  64

74 + 64	- 100
<u>= 38</u>	

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# Binary Arithmetic

- Adding 1-bit numbers

- Half adder ←

- Full adder ←

$$\left\{ \begin{array}{l} x_i \quad y_i \\ c_{i-1} \end{array} \right.$$

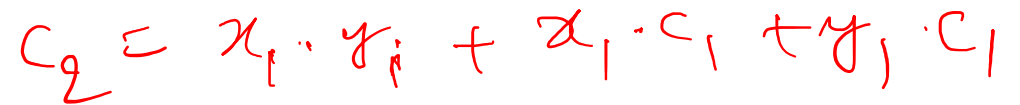
- Adding N-bit numbers

- Combination of full adders

$$\left\{ \begin{array}{l} s_i = x_i \oplus y_i \oplus c_i \\ c_{i+1} = x_i \cdot y_i + x_i \cdot c_i + y_i \cdot c_i \end{array} \right.$$

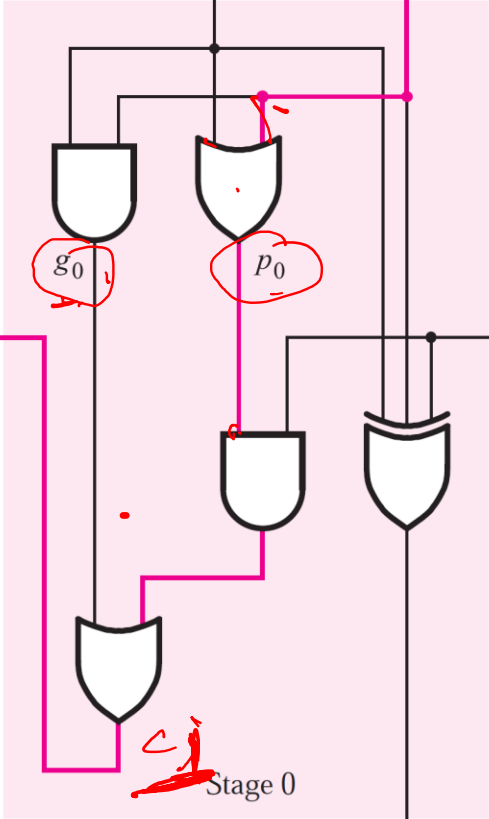
$n$ -bit number.

$x_{n-1} x_{n-2} \dots x_0$   
 $y_{n-1} y_{n-2} \dots y_0$

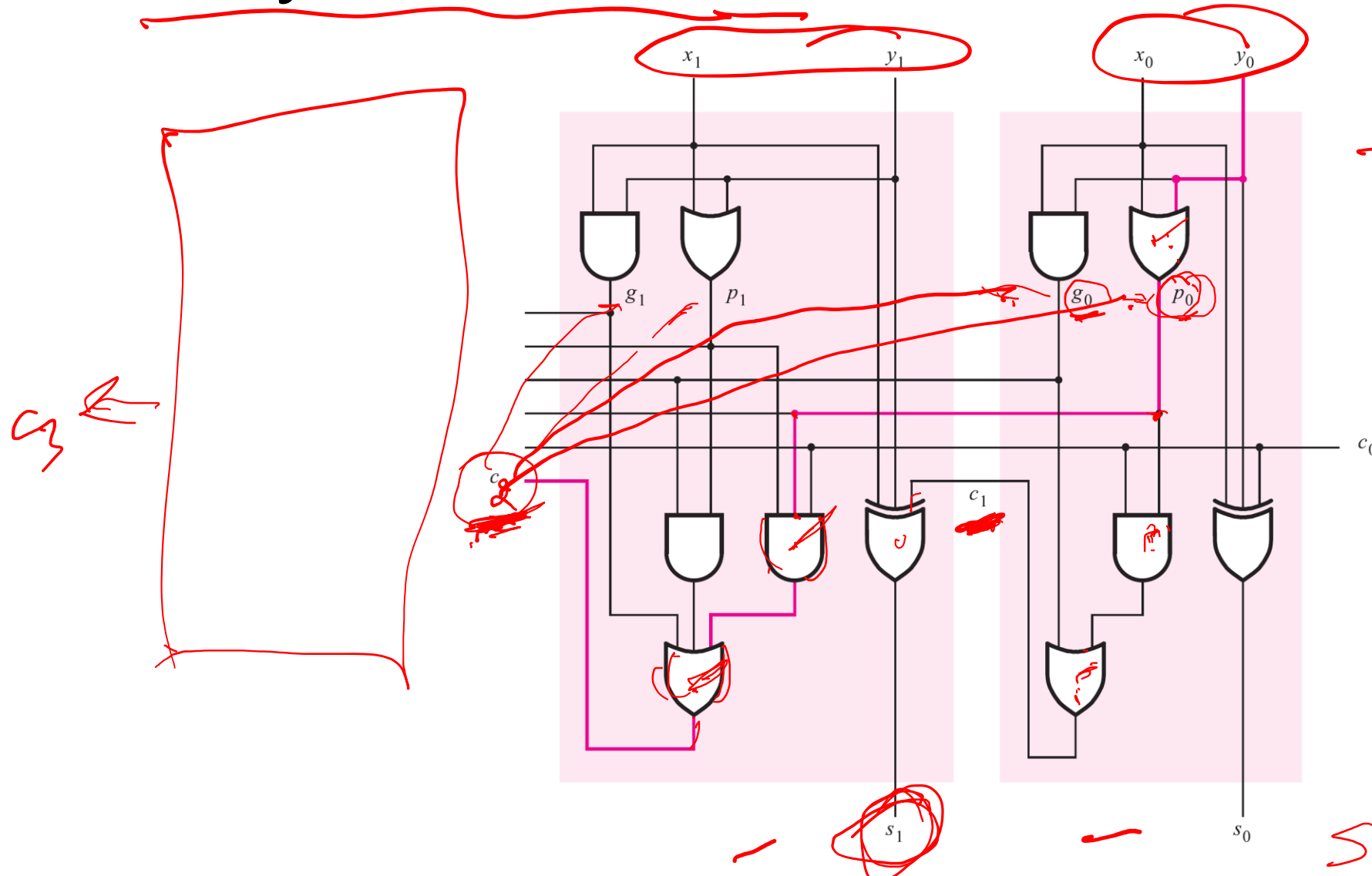




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$$2n+1$$

# Carry-Lookahead Adder Circuit



$n$   
 $\rightarrow 3$  gates  $\rightarrow$  carry

Total delay  
 $n$ -bit  
 $= 4$  gates

2-bit sum

$$S_i = x_i \oplus y_i \oplus c_i$$