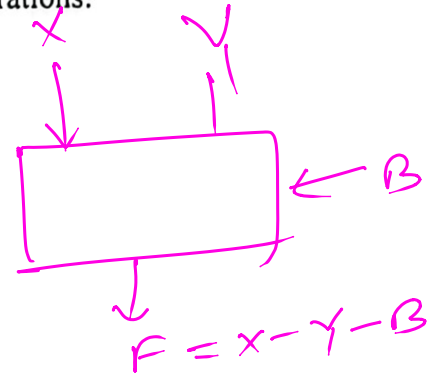


TF-22-23
AL

(b) Howard wants to demonstrate his engineering skills, but Sheldon sets a challenging constraint for him. Howard is tasked with designing a 4-bit Arithmetic Logic Unit (ALU), and the constraint is that he cannot use any parallel adder. Instead, he is only allowed to use parallel subtractors and logic gates for the ALU design. The ALU should have three selection variables, denoted as S_0 , S_1 , and S_2 . These selection variables control the ALU to perform various operations on two 4-bit inputs, Labelled as A and B. Your task is to help Howard design the 4-bit Arithmetic Logic Unit (ALU) so that it can do the following operations:

(14)

S_2	S_1	S_0	Operation
0	0	0	A - B
0	0	1	A + B
0	1	0	-A - B - 2
0	1	1	B - A
1	0	0	A XOR B
1	1	0	A AND B



$$-B = B' + 1$$

S_1	S_0	X_i	Y_i	B_i	Op
0	0	A	B	0	A - B
0	1	A	B'	1	$A - B' - 1$ $= A - (-B - 1) - 1$ $= A + B + 1 - 1$ $= A + B$
1	0	A'	B	1	$A' - B - 1$ $= -A - 1 - B - 1$ $= -A - B - 2$
1	1	A'	B'	0	$A' - B'$ $= (-A - 1) - (-B - 1)$ $= B - A$

$$x_i = s_1 \oplus A$$

$$y_i = s_0 \oplus B$$

$$B_i = s_1 \oplus s_0$$

now,

s_2	s_1	s_0	x_i	y_i	
1	0	0	A	B	$A \oplus B$

21 6775
675

$$\text{so, } B_i = \overline{s_2} (s_1 \oplus s_0)$$

s_2	s_1	s_0	x_i	y_i
1	1	0	\overline{A}	B

$$\text{output} \Rightarrow \overline{A} \oplus B = \overline{A} \overline{B} + AB$$

need AB

$$(B + K) \oplus \overline{A} = AB$$

$$\Rightarrow \overline{B} \overline{K} \overline{A} + (B + K) \cdot A = AB$$

$$\Rightarrow \overline{A} \overline{B} \overline{K} + AB + KA = AB$$

$$K = \bar{A}$$

finally

$$x_i = s_1 \oplus A$$

$$y_i = s_0 \oplus B + s_2 s_1 s_0' A'$$

$$b_i = \bar{s}_2 (s_0 \oplus s_1)$$