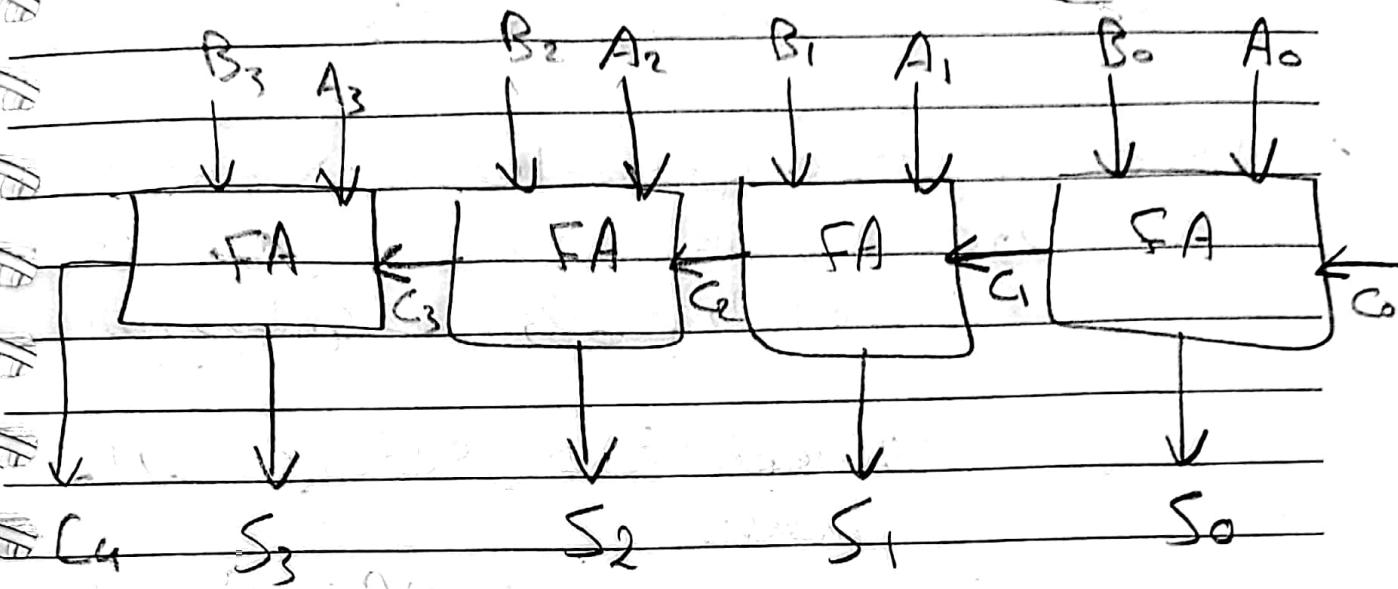


## Binary Adder

(2 Registers (3 nibbles) n-bit adder circuit)

 $C_0 \rightarrow$  zero out's carry
$$\begin{array}{l} A_3, A_2, A_1, A_0 \\ + B_3, B_2, B_1, B_0 \end{array}$$
 $A_0 + B_0 \rightarrow S_0, C_1$ (B<sub>1</sub>, A<sub>1</sub> is ignored) $C_1 + B_1 + B_1 \rightarrow S_1, C_2$ (B<sub>2</sub>, A<sub>2</sub> is ignored) $C_2 + A_2 + B_2 \rightarrow S_2, C_3$ (B<sub>3</sub>, A<sub>3</sub> is ignored) $C_3 + A_3 + B_3 \rightarrow S_3, C_4$ one  
zero (ignore) | overflow

لوحة حامة لها حجم واسع يصل إلى 4GBits على مساحة 5x5 cm²

إعمالو، (Register) overflow → one → one  
وأكملوا الـ Value إلى ما يزيد عن واحد وستة  
النتائج 5 Bits، ولذلك تحتاج إلى Bit الخاتمة

~~199~~ → unsigned) also (also (195)).  
Numbers

~~overflow happens when the value of a variable exceeds its maximum limit~~

~~overflow implies zero → zero Overflow))  
overflowed → one sign - flip flop~~

الخطوات  
1- Convert input to ASCII  
2- Detect overflow (if overflow)  
3- Handle overflow (if any)

# 2's Complement

1 + 1's Complement of (-2) 11

Decimal

Signed 2's Complement

+7

0111

+6

0110

+5

0101

+4

0100

+3

0011

+2

0010

+1

0001

+0

0000

-0

1111

-1

1110

-2

1101

-3

1100

-4

1011

-5

1010

-6

1001

-7

1000

-8

1000

~~دالات المعاين~~  $\rightarrow$  15 مع نزول Signed ١٥ اسپ و  
+ve ١٥ كانو ١٥ اسپ و Unsigned ١٥ اسپ

-ive grub +ve grub  $\rightarrow$  -8  $\rightarrow$  +7 مع نزول -  
جاء ٣ Bits في reg لانه عالي جدا  $\rightarrow$  الباقي هو عالي جدا  
unsigned & signed

٢٨ جاء ٣ Bits في register zero  $\rightarrow$  +7 اول الـ -  
0000 (Representation) zero  $\rightarrow$  -32000  $\rightarrow$  ١٥ اسپ

+ve ١٥ -ive ١٥ Representational ١٥ اسپ  
جاء ٣ Bits في register zero  $\rightarrow$  ١٥ Comp ١٥ اسپ  
result ١٥ اسپ

$$\begin{array}{r} +5 \\ \boxed{-5} \end{array} \rightarrow \begin{array}{l} 0101 \\ 1010 \quad 1\text{comp} \\ = 1011_2 + 1 \end{array}$$

one ١ Bit  $\rightarrow$  ٢ Bits  $\rightarrow$  -ve ١

$$\begin{array}{r} 1011 \\ \downarrow \downarrow \downarrow \\ -2^3 + 0 + 2^1 + 2^0 \\ -8 + 0 + 2 + 1 \\ \geq -5 \end{array}$$

## 2s Comp

$$-1s\text{Comp of Value} + 1 = 2^n - \text{Value}$$

where  $n = \text{number of Bits used}$   
 Value - like  $\underbrace{\dots}_{\text{list}} \rightarrow$

~~Explain~~ Ex: 2sComp of 6 in 8 bits

$$= 2^8 - 6 = 250 = (11111010)_{\text{Binary}}$$

$$\text{ex: } 13 - 6$$

15 اجل

السؤال  $13 - 6$   $\rightarrow$   
 بدل  $13$  و  $6$  و  $2s\text{Comp}$   $\rightarrow$   $13 + (-6)$

للتوصي  $\rightarrow$  Subtraction  $\rightarrow$   $13 + (-6)$   
 جزو  $13$  والباقي  $6$   $\rightarrow$   $2s\text{Comp}$   $\rightarrow$   $-6$  if  $2s\text{Comp}$   $\rightarrow$   $-ve$  if  
 if  $2s\text{Comp}$   $\rightarrow$   $+ve$  if  $2s\text{Comp}$   $\rightarrow$   $+ve$  if

$$\begin{array}{r} 13 \\ - 6 \\ \hline 7 \end{array}$$

a)  $2s\text{Comp} + 2s\text{Comp}$



$$2s\text{Comp}(-6) + 2s\text{Comp}(-5)$$

أمثلة  $\rightarrow$   $13 + (-6) = 7$  Bit 1  $\rightarrow$   $13 + (-5) = 8$  Bit 1  $\rightarrow$   $(11111010) + (11111010) = 11110100$

for example

$$\begin{array}{r}
 & 1 & 1 & 1 & 1 \\
 -6 & & + & 1 & 1 & 1 & 0 & 0 \\
 + 13 & & & 0 & 0 & 0 & 1 & 0 & 1 \\
 \hline
 & + 7 & & & & & & & \\
 & & & 0 & 0 & 0 & 0 & 1 & 1 & 0
 \end{array}$$

Remember

$$(\pm A) - (+B) = (\pm A) + (-B)$$

$$(\pm A) - (-B) = (\pm A) - (+B)$$

~~Carry 1 is 2's complement we just~~  
~~call Plus溢出 if carry + ve~~

one, if overflow  $\rightarrow$  (Carry) (Carry) (Carry)  
~~Carry~~ - VR

Carry 1, zero, Result), 3 bits 2 Bits overflow  
~~at the end~~

(overflow if one  $\rightarrow$  Carry) (Carry) (Carry)  
 zero, sum is B if overflow - VR

Bit sum الباقي one (Old Carry) المتبقي

- we figure out what causes overflow if we see one  
فقط ما يسبب

- if 81 digit Carry is less than

→ Overflow

if Carry is  $1 + 1$  less than sum

carry goes to  $1 + 1 + 0$  zero فتحة

if  $1 + 1 + 1$  is one if 81 (Old Carry) المتبقي  
(Overflow) also add one carry to one

Sum في Bit آخر هو (Carry) + we need, مع 1

So (overflow) if Carry one (جاء) + we will have 1 again (أيضاً) لـ overflow

zero if one (أيضاً) لـ overflow

Overflow	last <del>Sum</del>	last Carry	before last Carry
Sum	Carry	Carry	
No	X (Same)	X	-
Yes	X (different)	Y	
No	X (Same)	X	
Yes	X (different)	Y	

(No overflow) if (last Carry), (last Sum) 1 \*

(Overflow) if (last Carry) - \*

(No overflow) if (last Carry) 1, last (Carry) 1 \*

(No overflow) if (last Carry) 0 \*

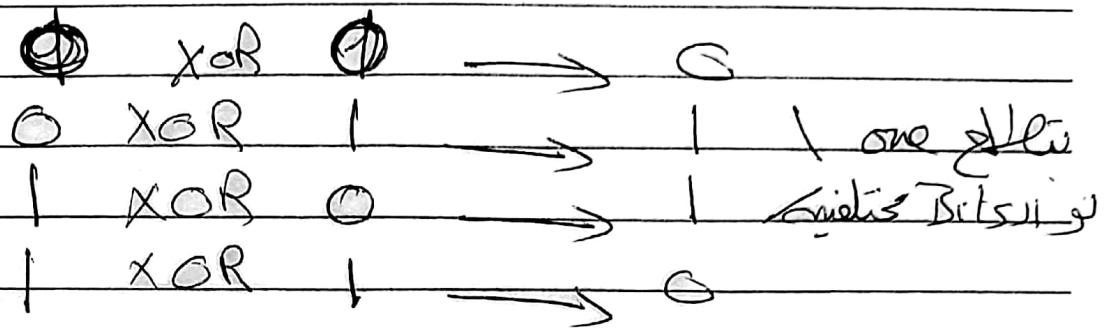
(overflow) if (last Carry) 1 \*

(overflow) if (last Carry) 0 \*

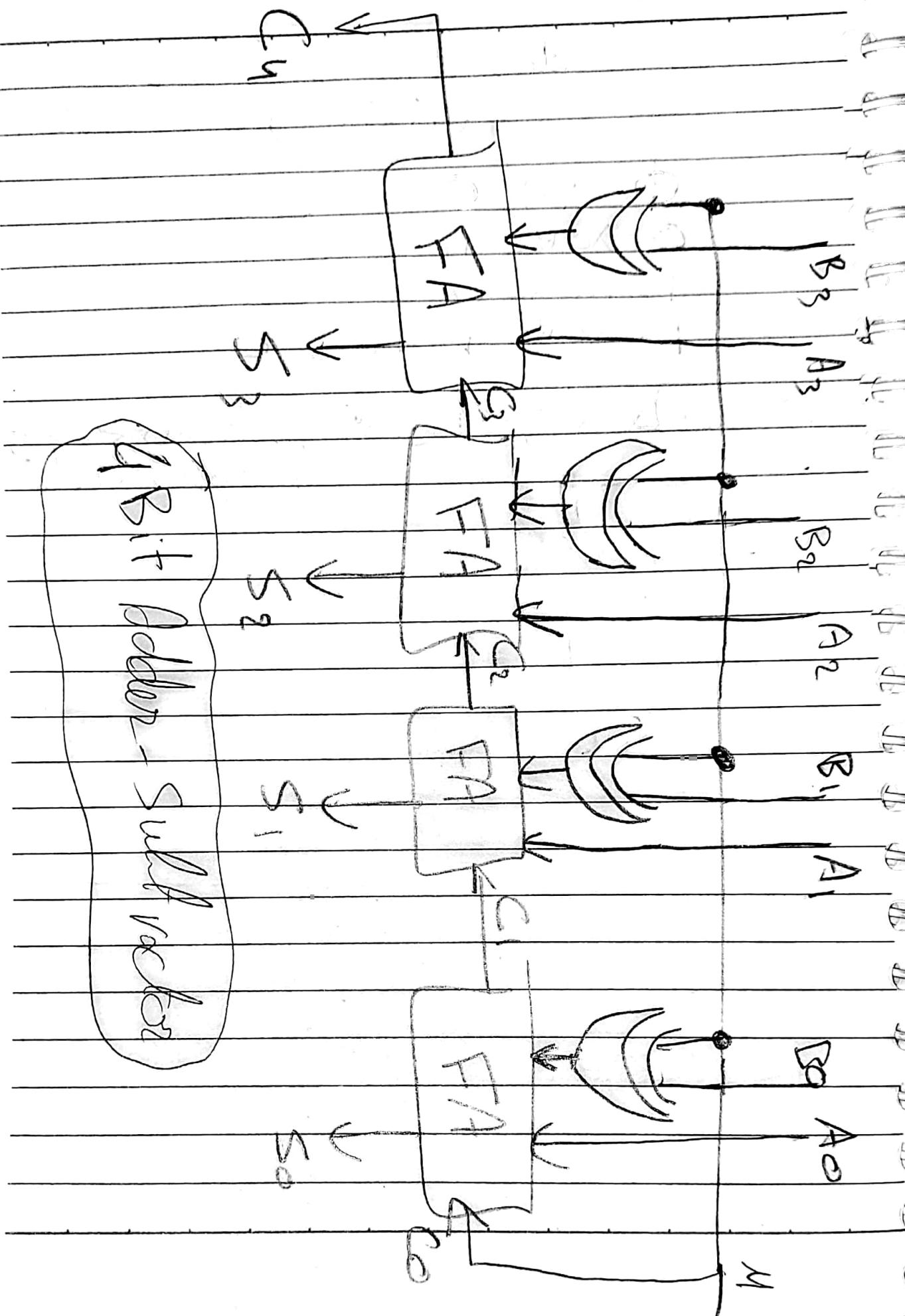
(overflow) if (last Carry) 1 \*

(overflow) if (last Carry) 0 \*

overflow ~~keep~~ met in الـ XOR ~~carry~~ (XOR) one using



الـ XOR لـ Detection of overflow task



$$0 \text{ XOR } 0 \Rightarrow 0$$

$$1 \text{ XOR } 0 \Rightarrow 1$$

$$0 \text{ XOR } 1 = 1$$

$$0 \text{ XOR } 1 = 1$$

$$1 \text{ XOR } 1 = 0$$

Inputs  $A, B$  gets Subtracts Add in Circuit  
Lgbt, C11M  $\rightarrow$  1G11

Adds بحسب Full Adder  $\therefore C_0 = 0 \leftarrow M=01\right)$   
 $B_0 \leftarrow B_0 \text{ ملخص XOR}$

Note that  $0 \text{ XOR } 1 = 1$

CS سهل FA  $\rightarrow$  ملخص  $B_0$ ,  $A_0$  فحسب

$B_0$  من XOR, A يدخل من FA و ملخص  $B_0$  من FA  
Sum, Carry Full Adder  $\rightarrow A, B$  يدخل  $B$  بحسب C11

Builds 11Bit (Adder) Circuit (سimplifies)

Subtracting  $A - B$  Subtraction  $M=11\right)$

2s Comp Circuit  $\rightarrow$  Subtraction

$A = 1sB, B = 1s(M - 1)$  ملخص

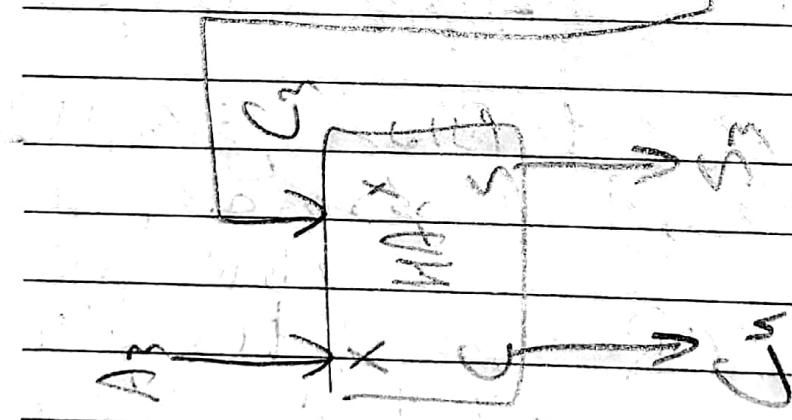
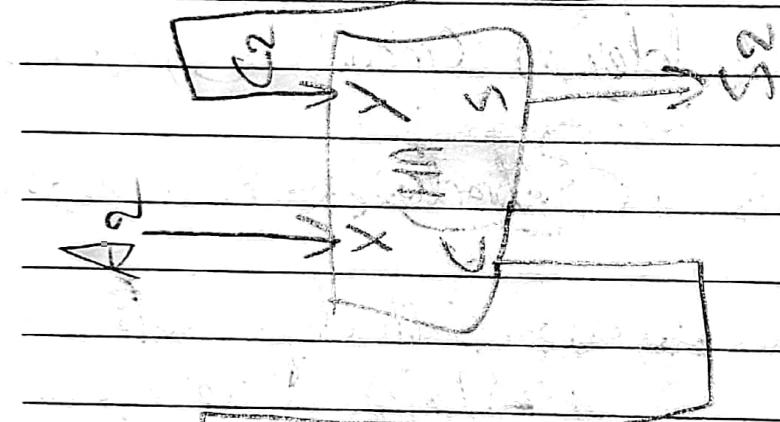
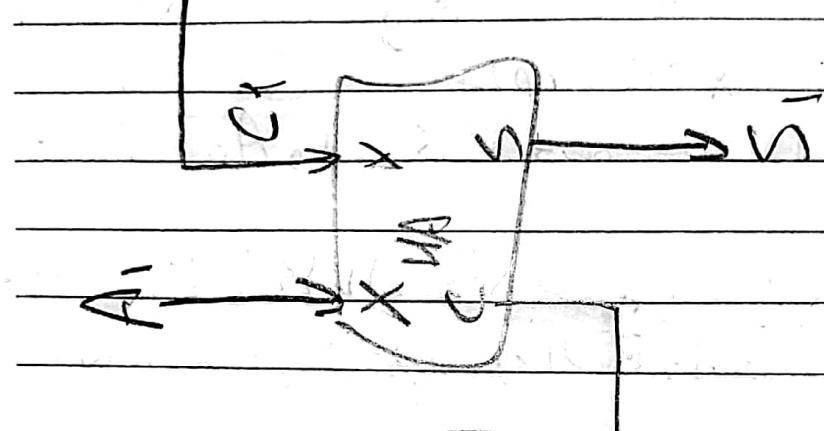
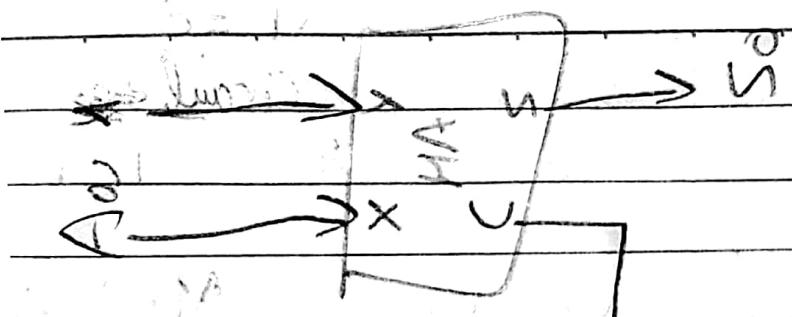
$C_0 + 1$  ملخص  $\therefore C_0 = 1, M = 11 \leftarrow 2s \text{ Comp of } B$

XOR 1 ملخص  $C_0$  ملخص  $A$  ملخص  $M, B$  ملخص

Note that  $1 \text{ XOR } 0 \rightarrow \text{Not}(C_0 \oplus B)$

one 1 لجس ملخص  $B \rightarrow$  1 لجس Compensation لجس ملخص  
circuit ملخص  $S_0, S_{10} \leftarrow A$  ملخص  $(B_0)$

2s Comp  $\infty$  one,  $(B_0)$  ملخص  $A$  ملخص



Binary increments  
+ Bi.

+ 1 Jadi will give  $(A + 1)$  और लिपि increases  
4 Bits mein किसी जूही तिक्ष्णीय input 11 है

$C_4 \ C_3 \ C_2 \ C_1$

$\downarrow$   
 $A_3 \ A_2 \ A_1 \ A_0$

1

$C_4 \ S_3 \ S_2 \ S_1 \ S_0$

Steps

~~Carry propagate one step at a time~~  
~~Add carry~~

$A_0 + 1 \rightarrow S_0, C_1$

$C_1 + A_1 \rightarrow S_1, C_2$

$C_2 + A_2 \rightarrow S_2, C_3$

$C_3 + A_3 \rightarrow S_3, C_4$

$C_4 \rightarrow \text{overflow}$

~~15 + 1 = 16~~  
~~5 Bits overflow~~

~~1 1 1 1~~

ex

$$\begin{array}{r} 1 1 1 1 \\ + 1 + 1 \\ \hline \end{array} \quad 15$$

1

0 0 0 0 16

overflow

# GBit Arithmetic Circuit

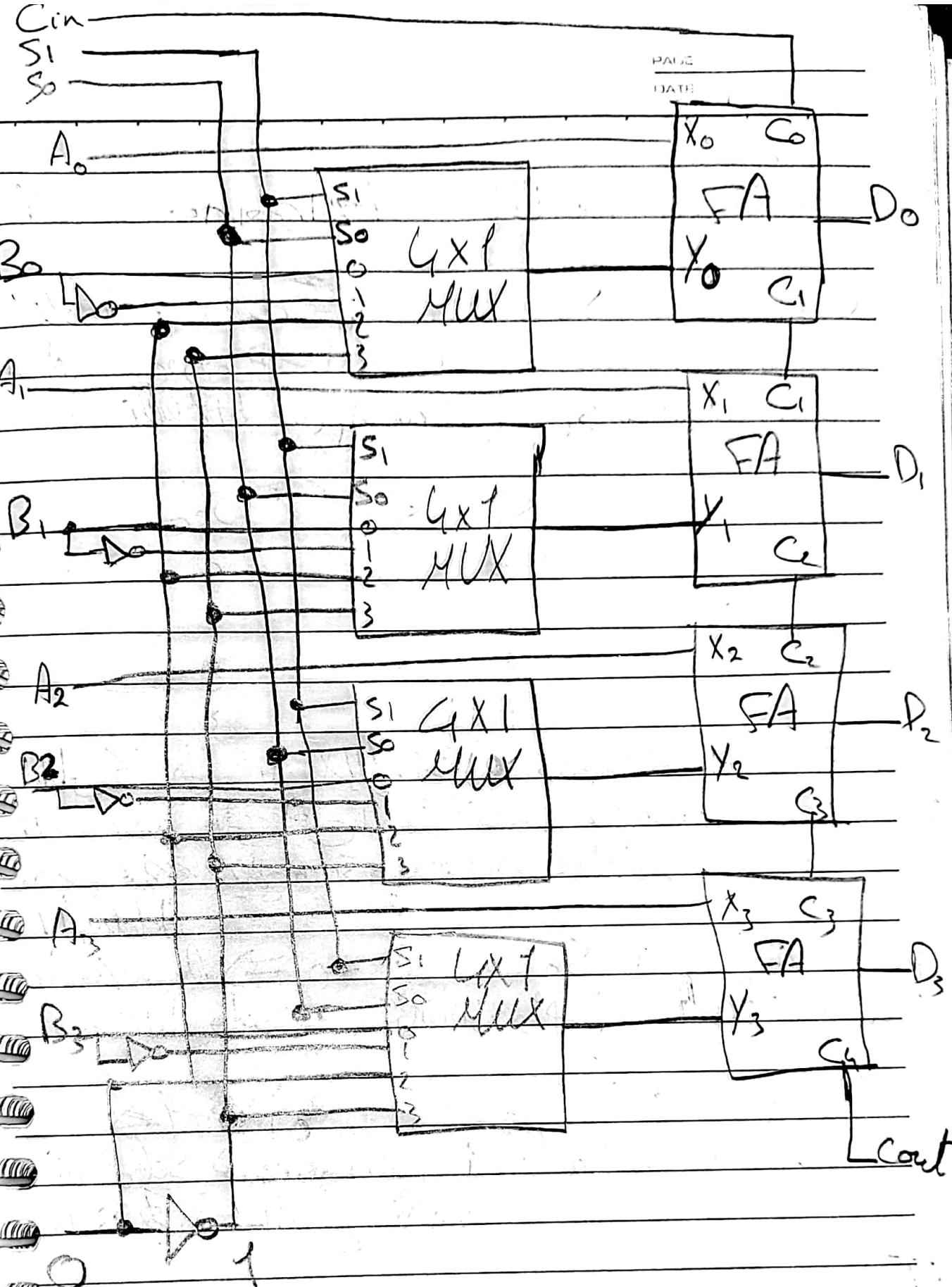
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<del>Inputs</del>	<del>S<sub>i</sub></del>	<del>S<sub>o</sub></del>	<del>C<sub>in</sub></del>	<del>Select</del>
1	0 0 0 0	S <sub>i</sub>	S <sub>o</sub>	Y
1	1 0 0 - - 0 0	S <sub>i</sub>	S <sub>o</sub>	Y
1	0 0 - - 0 - 0	S <sub>i</sub>	S <sub>o</sub>	Y
1 1 0 0 0 1 0 0	D	Y	X + C <sub>in</sub>	Input

$$\begin{array}{r}
 A + B + 1 \\
 A + B + 1 \\
 \hline
 A + B + 1
 \end{array}$$

$$\begin{array}{r}
 D = A + Y + C_{in} \\
 D = A + X + C_{in}
 \end{array}$$

Operation	Out Put
Add	A + B + 1
Add with Carry	D = A + Y + C <sub>in</sub>
Subtract with Borrow	D = A + X + C <sub>in</sub>
Transfer A	A
Increment A	A + 1
Decrement A	A - 1
Transfer A	A



## Arithmetic Circuit

### 2 Selectors (1 Cin) 3 "bit Operations" (of 4 bit) Circuit

1 race

1]  $C_{in} = 0, S_0 = 0, S_1 = 0 \Rightarrow$  Adder

والمدخلات  $A_0, A_1$  تك足  $C_{in}$ ،  $S_0$  والنتيجة  $S_1$  FA J1  
الخواص  $S_0$  هي دالة  $S_1$ ،  $S_1$  هي دالة  $S_0$  (Multiplexer)

$S_0$	$S_1$	Dec
0	0	0
0	1	1
1	0	2
1	1	3

( $S_0 = 0, S_1 = 0$ )  $\Rightarrow$  مخرج المجموع  $S_0, S_1$   $\Rightarrow$  مخرج المجموع  $S_0, S_1$

0  $\Rightarrow$   $C_{in}, A_0$  مع المدخل  $B_0$   $\Rightarrow$  المخرج  $S_0, S_1$   $\Rightarrow$  Zero

أي  $C_{in} = 0, A_0 = 0, B_0 = 0 \Rightarrow S_0 = 0, S_1 = 0$

Adding J1  
2]  $C_{in} = 1, S_0 = 0, S_1 = 0 \Rightarrow$  Add w/Carry  
والمدخل  $A, B$  مع المدخل  $C_{in}$   $\Rightarrow$  المخرج  $S_0, S_1$

3]  $C_{in} = 0, S_0 = 0, S_1 = 1 \Rightarrow$  Add w/Selection J1  
فالمدخل  $A, B$  مع المدخل  $S_1$   $\Rightarrow$  المخرج  $S_0, S_1$

$A + B$  مع  $S_1$

4]  $C_{in} = 1, S_0 = 0, S_1 = 1 \Rightarrow$  Add w/Case J1  
أي  $C_{in} = 1, S_1 = 1$  في أي حال، المخرج  $S_0, S_1$   $\Rightarrow$  المخرج  $S_0, S_1$

$A + 2^{10} \text{ comp. } B$   $\Rightarrow$   $S_0, S_1$

$$\begin{array}{r} 0001 \\ \times 1102 \\ \hline + 0001 \\ \hline 15 \end{array}$$

23 Comp of  $T_2 = 1$   
 $\text{oooo} \vdash \text{||||}$

PAGE

DATE

15 } 8000

$$\text{Lin} = 0, S_0 = 0, S_1 = 1$$

الآن تعالوا نلقي 2 قيمتين  $c=0$  و  $c=1$  في  $A$  فما هي النتيجة؟

$$C_{in} = 1, S_0 = 0, S_1 = 1$$

الخطوة A) حل معادلة  $A + 11d = 11$

+ If increment ( $\text{dig}(C)$ ) as if it will come back

$$7 \quad C_0 = 0, S_0 = 1, S_1 = 1$$

~~15g~~ 110 Unsigned 111 11

~~Comp 11~~ - 1 (and Signed) 11/11/11  
Sgt 2 Comp 11 C/S A 11/20/11

$$A + 2s \text{Comp}(\#1)$$

= A 1

$$28) S_0 = 1, S_i = 1, S_{in} = 1$$

طريق رقم 3 بـ(جبل عالي) على خط سكة حديد مصر

$$A - 1 + 1$$

— #

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