CSE 306_Assignment1
4-Bit Arithmetic and Logic Unit

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1 Design of Arithmetic Unit

Truth Table : Arithmetic Operations

CS_2	CS_1	$CS_0(C_{in})$	X_i	Y_i	F	Arithmetic Operation
0	0	0	A_i	$\overline{B_i}$	$A-B-1$	Subtract with borrow
0	0	1	A_i	$\overline{B_i}$	$A-B$	Subtract
0	1	0	A_i	1	$A-1$	Decrement A
0	1	1	A_i	1	A	Transfer A

Subtract with borrow :
$= A - B - 1$
$= (A + \overline{B} + 1) - 1$
$= A + \overline{B}$
$= A + (2^n - 1 - B)$
$= 2^n + (A - B - 1)$

Subtract :
$= A - B$
$= A + \overline{B} + 1$
$= A + (2^n - 1 - B) + 1$
$= 2^n + (A - B)$

Decrement A :
$= A - 1$
$= A + 2^n - 1$
$= 2^n + (A - 1)$

Transfer A :
$= A$
$= A + 2^n - 1 + 1$
$= 2^n + A$

So we have,

$X_i = A_i$

$Y_i = \overline{CS_1}.\overline{B_i} + CS_1 = \overline{(CS_1 + B_i)} + CS_1$

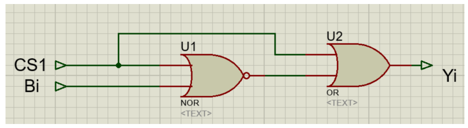

Figure 1: Design of Yi

2 Design of Logic Unit

Truth Table : Logical Operations

CS_2	CS_1	$CS_0(c_{in})$	X_i	Y_i	$F_i = X_i \oplus Y_i$	Operation
1	0	0	$A_i + \overline{B_i}$	B_i	$A_i.B_i$	AND
1	0	1	$A_i + \overline{B_i}$	B_i	$A_i.B_i$	AND
1	1	0	$\overline{A_i}$	1	$\overline{A_i}$	Complement A
1	1	1	$\overline{A_i}$	1	$\overline{A_i}$	Complement A

Explanation: We can't modify Y_i because that would change the arithmetic operations and neither can omit A_i in any input, So we change X_i.
Let,
$X_i = A_i + K_i$

$F_i = X_i \oplus Y_i$
$F_i = (A_i \oplus K_i) \oplus \overline{B_i}$
$F_i = (A_i \oplus K_i)B_i + \overline{(A_i \oplus K_i)}.\overline{B_i}$
$F_i = A_iB_i + K_iB_i + \overline{A_i}.\overline{K_i}.\overline{B_i}$

Here the desired operation is A_iB_i. So putting $K_i = \overline{B_i}$
$F_i = A_iB_i$

$F_i = X_i \oplus Y_i$
$F_i = X_i \oplus 1$
$F_i = \overline{X_i}$
$F_i = \overline{A_i + K_i}$

Here the desired output is $\overline{A_i}$. So putting $K_i = 0$
$F_i = \overline{A_i}$

So we need $K_i = \overline{B_i}$ when we will do AND operation and $K_i = 0$ for NOT operation.

We get,

$X_i = A_i + CS_2.\overline{CS_1}.\overline{B_i} = A_i + CS_2\overline{(CS_1 + B_i)}$

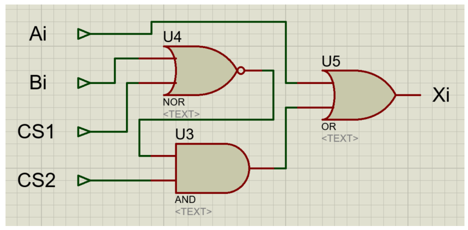

Figure 2: Design of X_i

So finally we have,

$X_i = A_i + CS_2\overline{(CS_1 + B_i)}$

$Y_i = \overline{(CS_1 + B_i)} + CS_1$