Assignment 2: CS220

Carry Look-Ahead Adder and Johnson Counter

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1 8-bit Carry Look Ahead Adder

1.1 Description

A carry look-ahead adder reduces the propagation delay by defining and using two 1-bit Boolean variables ***carry generate*** G_i and ***carry propagate*** P_i as follows:

$P_i = A_i \oplus B_i$
$G_i = A_i B_i$

Let S_i be the sum and C_i be the ***sum*** and ***carry*** respectively. Then:

$S_i = P_i \oplus C_i$
$C_{i+1} = G_i + P_i C_i$

Now, ***carry*** C_i can be expressed as:

$C_1 = G_0 + P_0 C_0$
$C_2 = G_1 + P_1 C_1 = G_1 + P_1 G_0 + P_1 P_0 C_0$

As you can see that we have expanded C_1 so that C_2 doesn't have to wait for C_1 to get evaluated. Similarly we can expand other C_i's.

1.2 Circuit Diagram

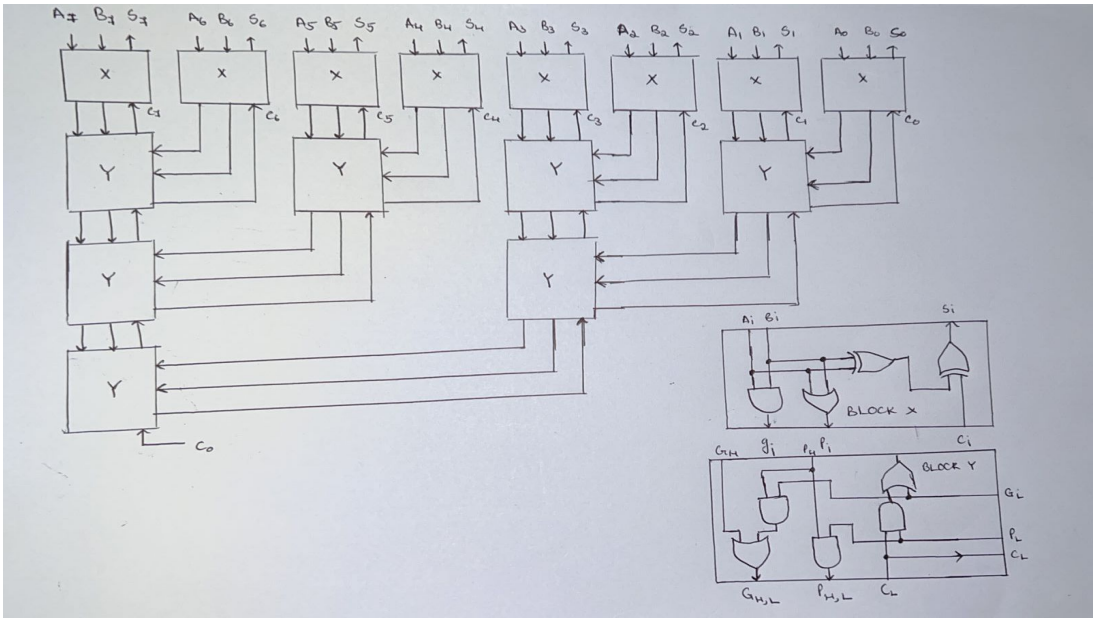

Figure 1: Carry Look Ahead Adder

2 8-bit Johnson Counter

2.1 Description

An 8-bit Johnson counter is a synchronous counter requiring 8 D flip-flops. It is triggered at the positive edge of the clock and the positive edge of reset. In the case of rest, it restarts its sequence of states by resetting the state to 8b'00000000.
The next state logic involves shifting the previous state logic while also using it as an input. To create the next state, the previous state is shifted to the right by 1 bit, and the rightmost (least significant) bit's complement forms the leftmost (most significant) bit of the next state. The changing of state happens at the positive edge of the clock or when reset signal is changed to 1.
The hardware implementation of a Johnson counter is done using 8 D flip-flops. We connect the output of each flip-flop to the input of the flip-flop representing the bit to the immediate right. However, the complement of the output of the flip-flop representing the least significant bit is fed to the input of the flip-flop representing the most significant bit.

2.2 Circuit Diagram

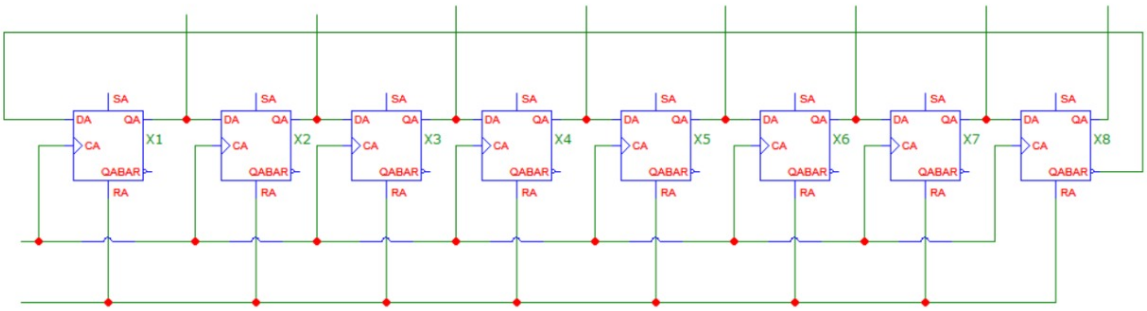

Figure 2: Johnson Counter (made with microcap)

2.3 Truth Table

Here CP is clock pulse and Q_i's are D flip-flops such that Q_1 represents the most significant bit.

CP	Q_1	Q_2	Q_3	Q_4	Q_5	Q_6	Q_7	Q_8
0	0	0	0	0	0	0	0	0
1	1	0	0	0	0	0	0	0
2	1	1	0	0	0	0	0	0
3	1	1	1	0	0	0	0	0
4	1	1	1	1	0	0	0	0
5	1	1	1	1	1	0	0	0
6	1	1	1	1	1	1	0	0
7	1	1	1	1	1	1	1	0
8	1	1	1	1	1	1	1	1
9	0	1	1	1	1	1	1	1
10	0	0	1	1	1	1	1	1
11	0	0	0	1	1	1	1	1
12	0	0	0	0	1	1	1	1
13	0	0	0	0	0	1	1	1
14	0	0	0	0	0	0	1	1
15	0	0	0	0	0	0	0	1
16	0	0	0	0	0	0	0	0