

## Problem 1

Both LOW-to-HIGH and HIGH-to-LOW transitions cause positive transitions on the outputs of three gates (every second gate), and negative transitions on the other three. Thus, the total delay in either case is:

$$t_p = 3t_{pLH(74LS00)} + 3t_{pHL(74LS00)} = 3 \times 15 + 3 \times 15 = 90 \text{ ns}$$

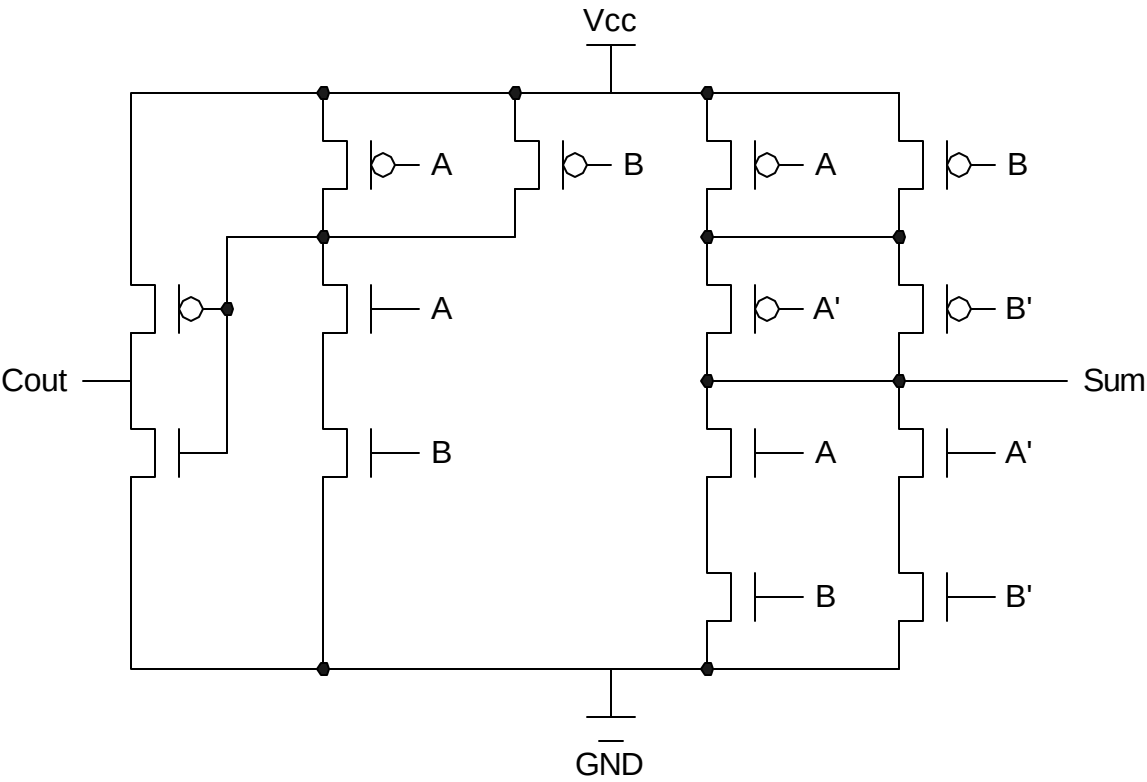
Since  $t_{pLH}$  and  $t_{pHL}$  for a 74LS00 are identical, the same result is obtained using a single worst-case delay of 15 ns.

## Problem 2

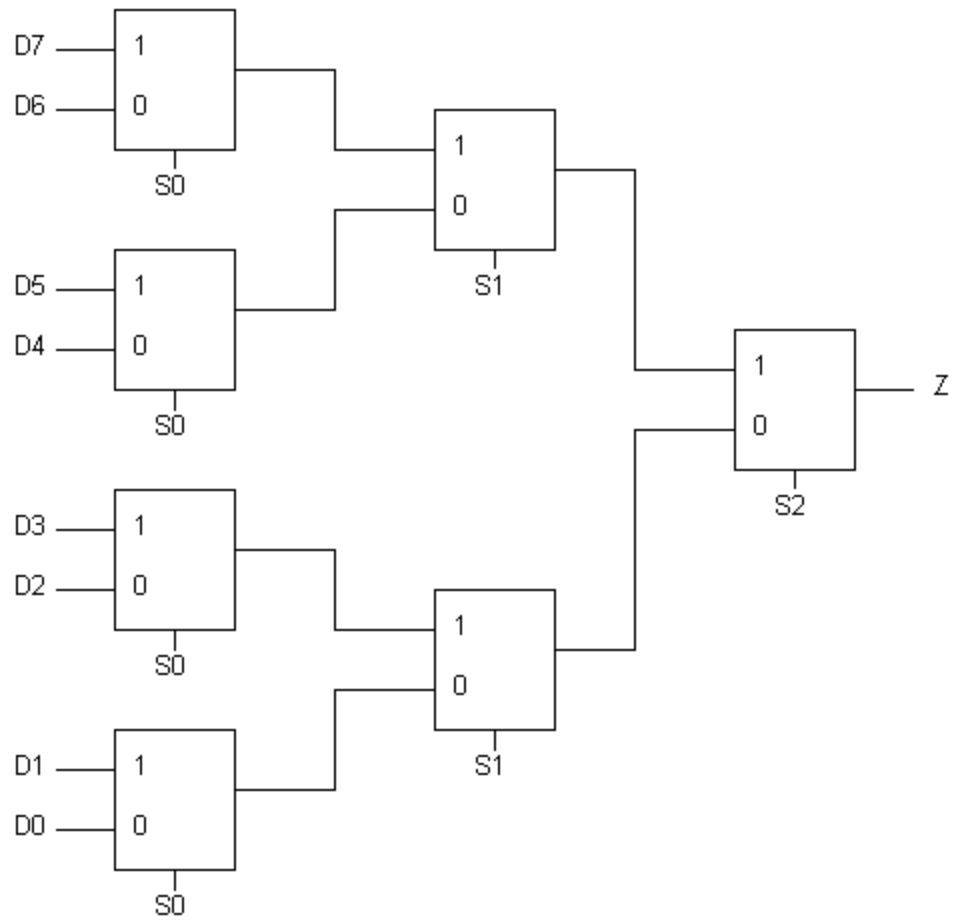
The smallest typical delay through one 'LS86 for any set of conditions is 10ns. Use the rule of thumb, "minimum equals one-fourth to one-third of typical", we estimate 3 ns as the minimum delay through one gate. Therefore, the minimum delay through the four gates is estimated at 12 ns.

The above estimate is conservative, as it does not take into account the actual transitions in the conditions shown. For a LOW-to-HIGH input transition, the four gates have typical delays of 13, 10, 10 and 20 ns, a total of 53 ns, so the minimum is estimated at one-fourth of this or 13 ns. For a HIGH-to-LOW input transition, the four gates have typical delays of 20, 12, 12 and 13 ns, a total of 57 ns, so the minimum is estimated at 14 ns.

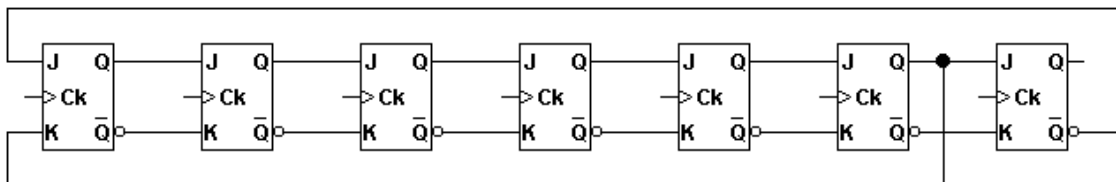
**Problem 3**



## Problem 4



## Problem 5



Assuming that the counter starts with initial state 0000000, the output sequence is the following:

| Binary  | Decimal |
|---------|---------|
| 0000000 | 0       |
| 1000000 | 64      |
| 1100000 | 96      |
| 1110000 | 112     |
| 1111000 | 120     |
| 1111100 | 124     |
| 1111110 | 126     |
| 0111111 | 63      |
| 0011111 | 31      |
| 0001111 | 15      |
| 0000111 | 7       |
| 0000011 | 3       |
| 0000001 | 1       |
| 0000000 | 0       |

## Problem 6

For each transition of the Mealy machine that outputs 1 we create a new state with output 1 and its transitions being the same as the ones from the state that the initial transition would lead us to.

| PS    | x=a   | x=b   | x=c   | z |
|-------|-------|-------|-------|---|
| $A_0$ | E     | $B_1$ | $B_0$ | 0 |
| $B_0$ | $F_0$ | $B_0$ | $A_1$ | 0 |
| E     | $A_0$ | $F_1$ | $F_0$ | 0 |
| $F_0$ | $B_0$ | $A_0$ | $F_0$ | 0 |
| $A_1$ | E     | $B_1$ | $B_0$ | 1 |
| $B_1$ | $F_0$ | $B_0$ | $A_1$ | 1 |
| $F_1$ | $B_0$ | $A_0$ | $F_0$ | 1 |