

Embedded Real-Time Systems (AME 3623)

Homework 3 Solutions

March 9, 2009

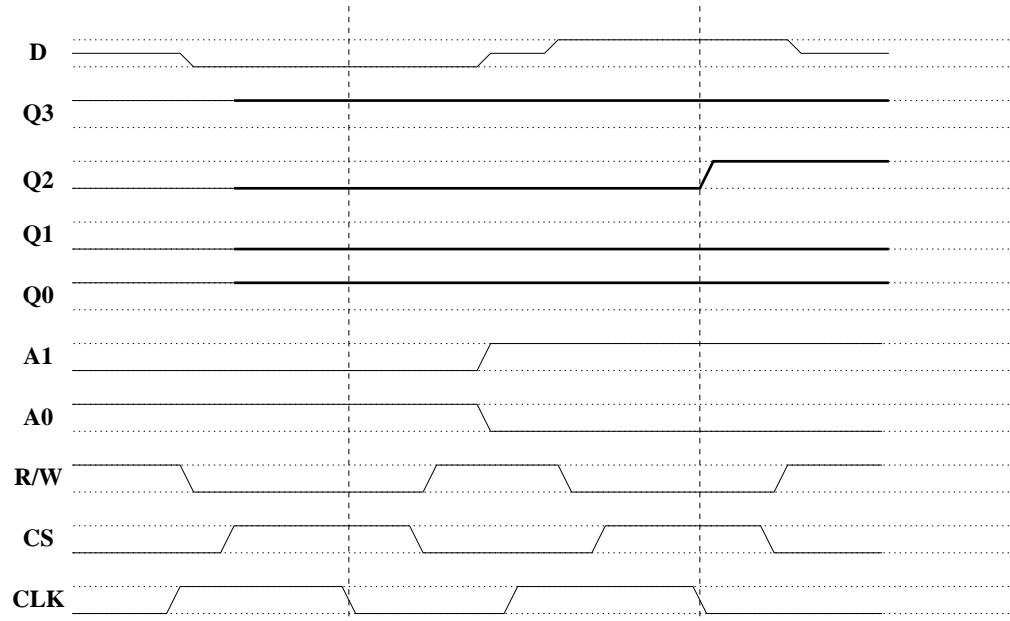
Question 1

(10pts) Consider the four-element memory “chip” that we discussed in class (each element is “one bit wide”). Given the following timing diagram, fill in the missing traces ($Q0$, $Q1$, $Q2$, and $Q3$).

Hint: first re-examine the rules for writing to and reading from a memory chip.

Both memory accesses are write operations; they affect the state of $Q1$ and $Q2$, respectively (but only when the clock transitions from high to low). However, the state of $Q1$ does not change.

(answer is shown in bold)

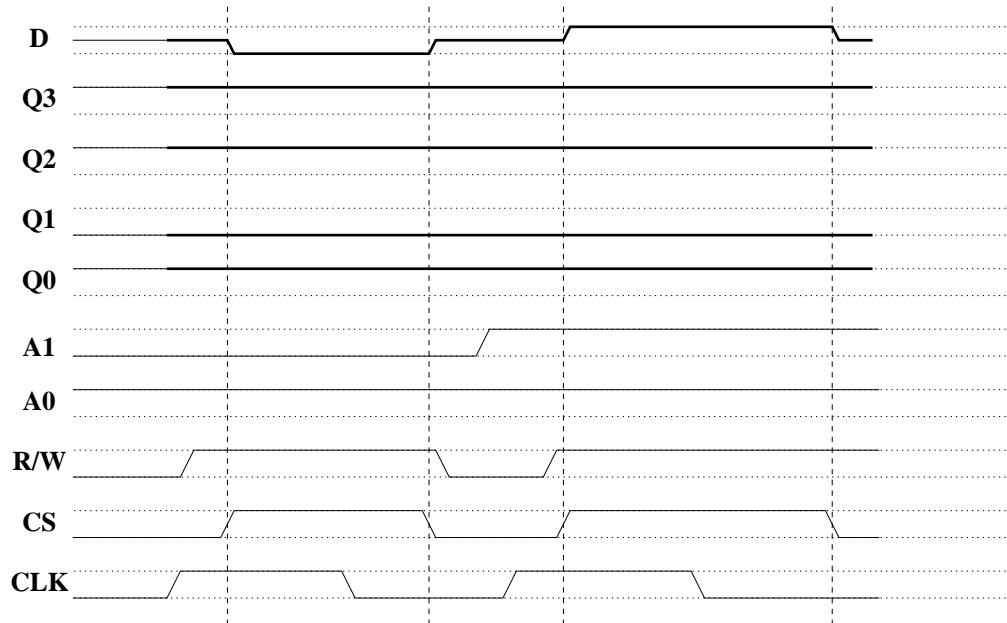


Question 2

(10pts) Consider the same four-element memory chip. Given the following timing diagram, fill in the missing traces (D , $Q0$, $Q1$, $Q2$, and $Q3$).

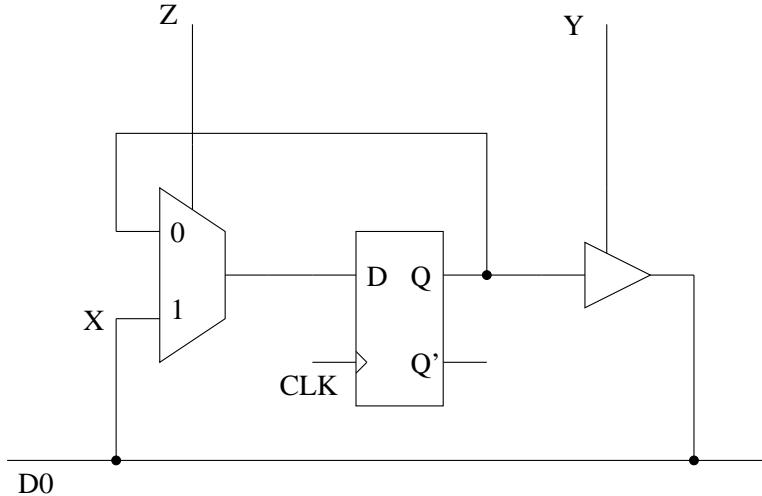
Both of these operations are read operations of elements $Q1$ and $Q3$. None of the memory elements change state. The data bus is driven during the entire time that the chip select line is high.

(answer is shown in bold)



Question 3

The following circuit is a partial implementation of a 1-bit memory sitting on the data bus $D0$.



1. (10pts) Suppose that Q is initially set to 1. If $Z = 0$, $Y = 0$, $D0 = 0$ and the clock transitions from high to low, what happens to Q ?

Because the multiplexer is selecting the Q input (back to D), the flip-flop does not change state.

2. (10pts) Suppose that Q is initially set to 1. If $Z = 1$, $Y = 0$, $D0 = 0$ and the clock transitions from high to low, what happens to Q ?

Because the multiplexer is selecting the $D0$ input, then the flip-flop copies the value of $D0$ (which is 0).

3. (10pts) Suppose that Q is initially set to 1. If $Z = 0$, $Y = 1$ and the clock transitions from high to low, what happens to $D0$ and when?

$D0$ is driven by the tri-state buffer as long as Y is set to 1 (the state of Q). (Since the multiplexer is selecting the Q input, Q does not change state when the clock transitions.)

4. (10pts) Generally, what is the meaning of Z ?

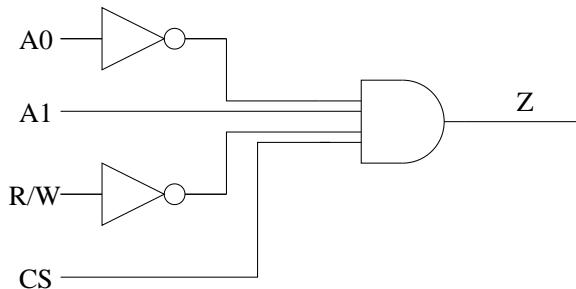
Z controls whether the memory will not change or whether it will copy the value from the data bus (the latter would be on the high-to-low transition of the clock). This copy happens only when $Z = 1$.

5. (10pts) Assume memory control signals in the previous problems (CS , R/W , $A1$, and $A0$), and that this is memory element number 2 (counting from 0). Give the truth table for Z .

In order for a write operation to a particular memory element to occur, we must have: $CS = 1$, $R/W = 0$, and $A1, A0 = 10$. So - all rows are zero (indicating no change in state), except for this one specific combination.

CS	R/W	$A1$	$A0$	Z
0	0	0	0	0
0	0	0	1	0
0	0	1	0	0
0	0	1	1	0
0	1	0	0	0
0	1	0	1	0
0	1	1	0	0
0	1	1	1	0
1	0	0	0	0
1	0	0	1	0
1	0	1	0	1
1	0	1	1	0
1	1	0	0	0
1	1	0	1	0
1	1	1	0	0
1	1	1	1	0

6. (10pts) Design a circuit that implements Z .



Question 4

1. (5pts) Briefly define *serial communication*.

Serial communication is the process of communicating between two points in which the data are transmitted one bit at a time along a single line.

2. (10pts) Under what conditions does the LED attached to port B, pin 1 flash?

```
while(1) {
    c = getchar();
    if(c >= '0' && c <= '9') {
        PORTB ^= 4;
    }
    PORTB ^= 2;
}
```

Every time a character is received the LED connected to pin 1 will flip state. Every time that the character is a digit, then the LED connected to pin 2 will flip state.