Embedded Real-Time Systems (AME 3623)
Homework 3 Solutions

March 9, 2009

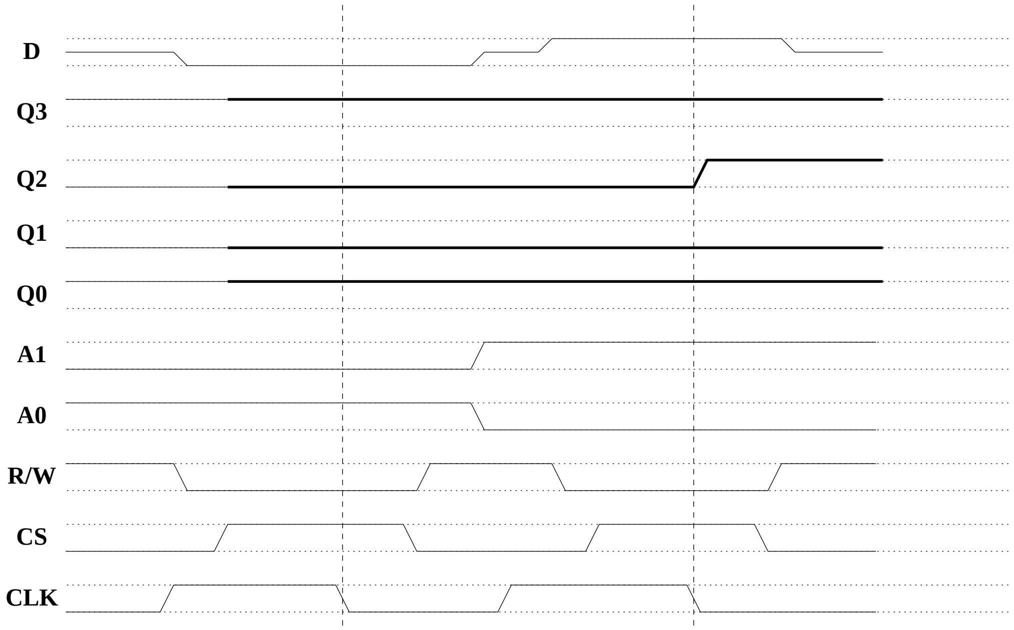
Question 1

(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)

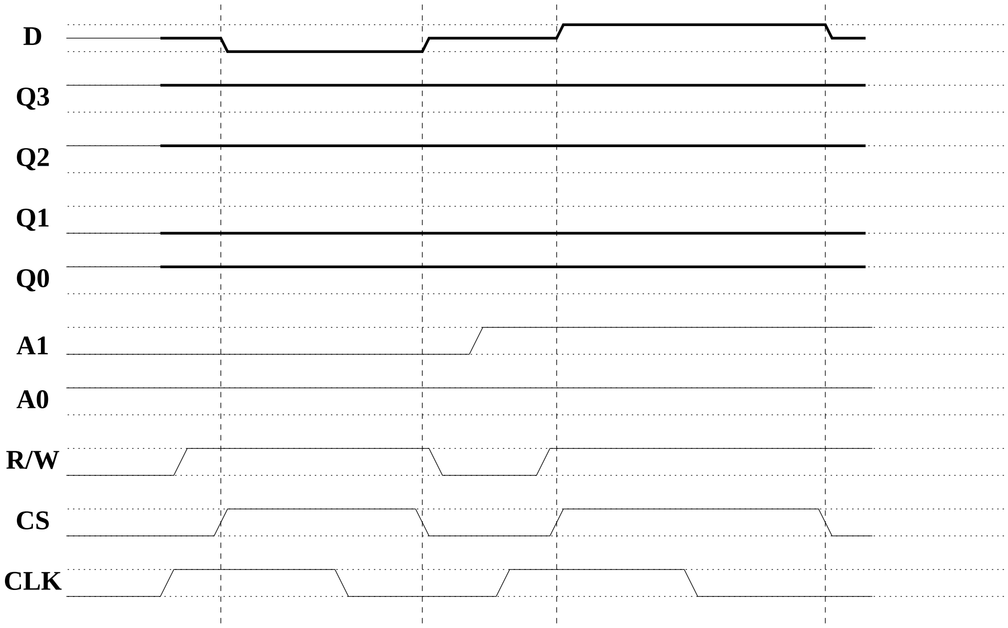


Question 2

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

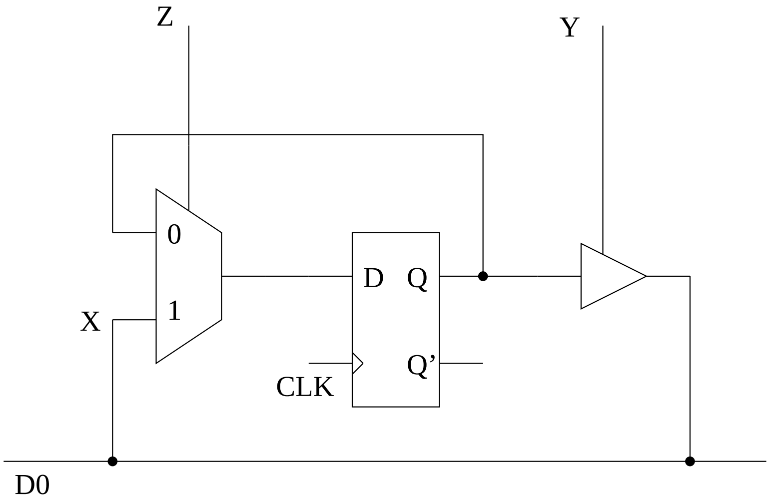
Both of these operations are read operations of elements Q1 and Q3. None of the memory elements change state. The data bus is driven during the entire time that the chip select line is high.

(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?

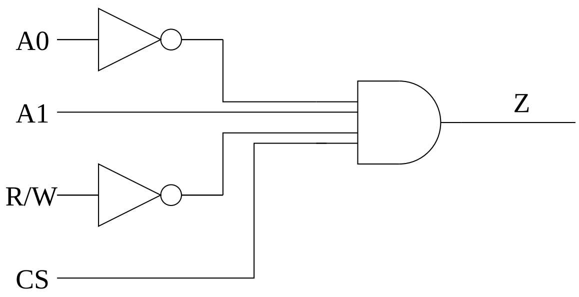
   Z controls whether the memory will not change or whether it will copy the value from the data bus (the latter would be on the high-to-low transition of the clock). This copy happens only when $Z = 1$.

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.