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

March 11, 2008

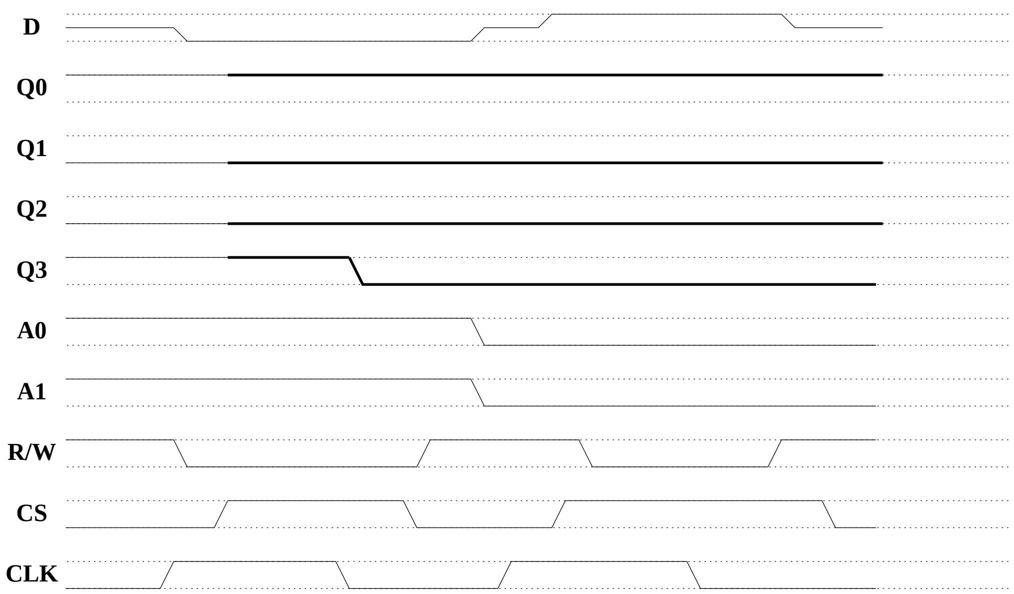
Question 1

(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 Q3 and Q0, respectively (but only when the clock transitions from high to low). However, the state of Q0 does not change.

(answer is shown in bold)

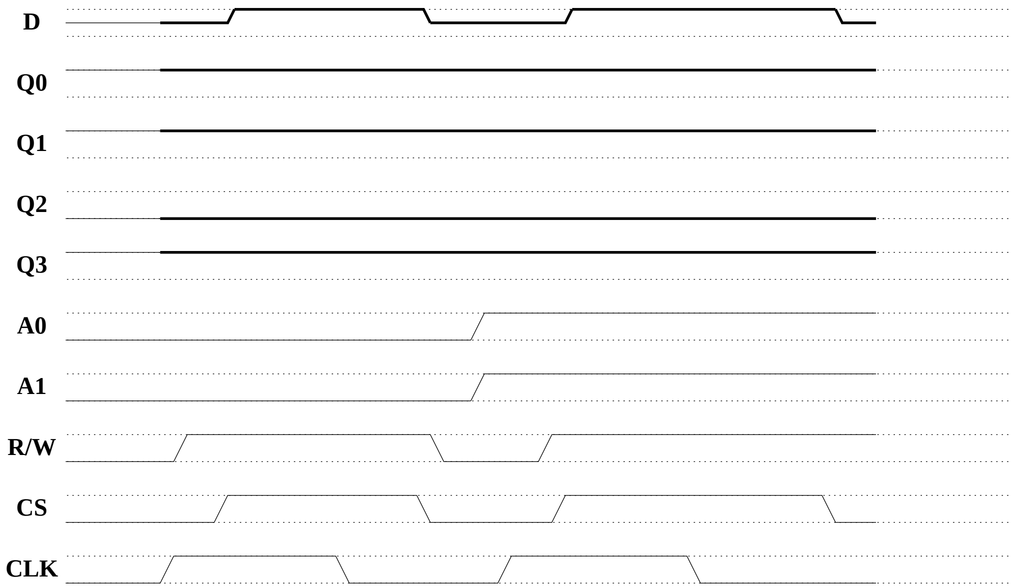


Question 2

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

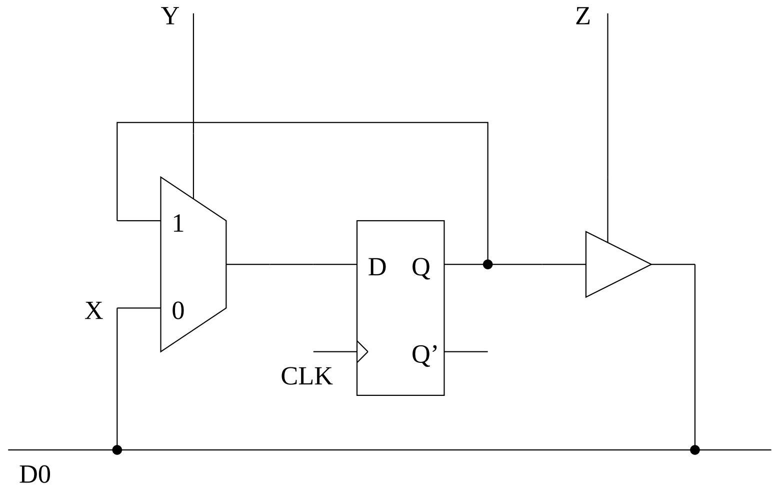
Both of these operations are read operations of elements Q0 and Q3. None of the memory elements change state. The data bus is driven during the entire time that the chip select line is high.

(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) What effect does signal Y have on writing to or reading from the memory?

   When $Y = 0$ and CLK transitions from high to low, the value on the data bus is stored in the memory (this is a write operation to the memory). The value remains unchanged when $Y = 1$ (the value of Q is copied to D), even when the CLK transitions from high to low.

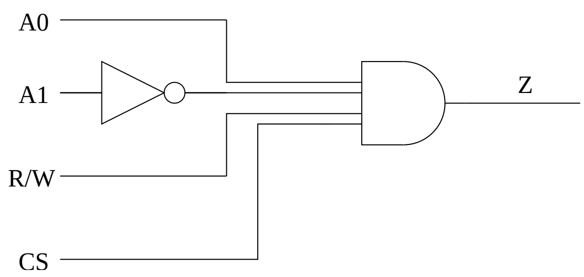
2. (10pts) What effect does signal Z have on writing to or reading from the memory?

   When Z is high, the value that is stored in the memory is written to the data bus (this is a read operation from the memory).

3. (10pts) Assume memory control signals in the previous problems (CS, R/W, $A1$, and $A0$), and that this is memory element number 1 (counting from 0). Give the truth table for Z.

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	0
1	0	1	1	0
1	1	0	0	0
1	1	0	1	1
1	1	1	0	0
1	1	1	1	0

4. (10pts) Design a circuit that implements Z.



Question 4

1. (5pts) Briefly explain the function of a *start bit* in serial communication.

   The start bit is transmitted from the sender to the receiver to indicate that a byte is about to be transmitted. This first bit is used to synchronize the clocks on both sides. This synchronization allows the two sides to agree as to when each of the bits in the subsequent byte are being transmitted.

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

```
while(1) {
   c = getchar();
   if(c >= 'a' && c <= 'z') {
      PORTB ^= 2;
   }
}
```

   Every time a lower case letter is received from the serial port, the LED state is flipped.