

# Embedded Real-Time Systems (AME 3623)

## Homework 3 Solutions

March 9, 2009

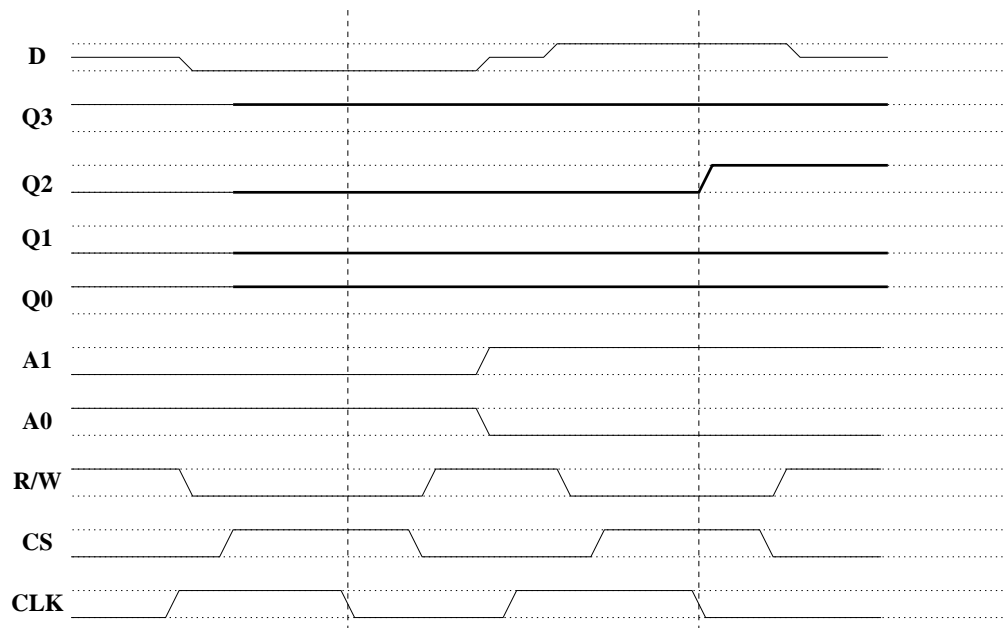
## Question 1

(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)*

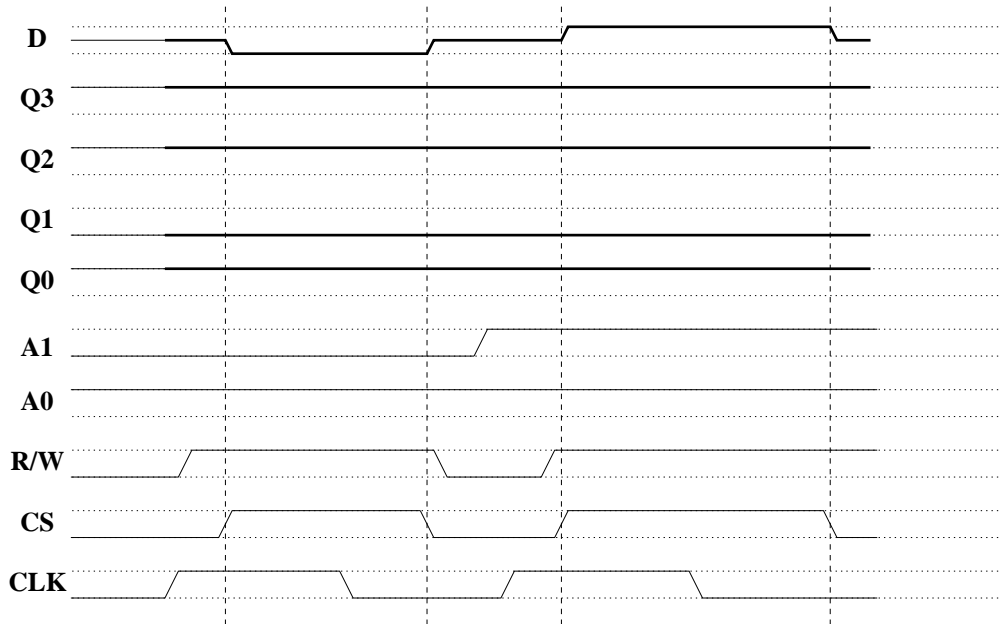


## Question 2

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

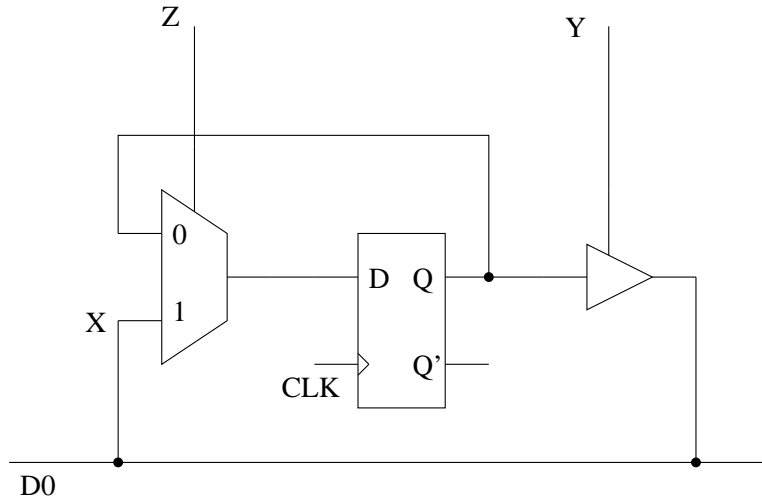
*Both of these operations are read operations of elements  $Q1$  and  $Q3$ . None of the memory elements change state. The data bus is driven during the entire time that the chip select line is high.*

*(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  $Z$ ?

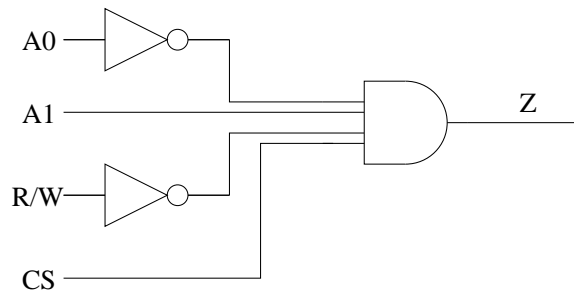
$Z$  controls whether the memory will not change or whether it will copy the value from the data bus (the latter would be on the high-to-low transition of the clock). This copy happens only when  $Z = 1$ .

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.