CSCI 463-1

Computer Systems Organization

Spring 2023

Homework #3  
 (60 points)

The characteristic table on slide 3f-47 and the truth table on 3f-48 both describe the behavior of the same sequential circuit.

Sequential circuits have values that change over time. That’s why instead of saying the output of this circuit is Q, we have to say that the output is Q(t), the value at clock tick t. You can think of the clock tick number as the number of ticks that the circuit has been running.

The value of a sequential circuit at time t+1 depends on the current values of the input variables but also depends on the value of the circuit at time t. Combinational circuits don’t need the clock tick number as an input because the value of the output depends only on the value of the input variable(s) and does not depend on the circuit’s previous behavior.

A characteristic table and a truth table are two ways to describe a sequential circuit. A truth table (see 3f‑48) for an example) has a row for each combination of input variables and possible previous value. The output column shows the new value of the circuit.

A characteristic table is a shorter way of writing the same information. On 3f‑47, you can see that the characteristic table has one row for each combination of input variables. How then can it show different values of the output depending on the circuit’s previous value? It does so using a variable in the output column. That variable contains the circuit’s previous value. Since that variable could have different values (0 or 1), it allows us to combine multiple cases in one row of the characteristic table.

1. Assume the rows of the characteristic table in 3f‑47 are numbered from top to bottom as 0, 1, 2 and 3. For each row of the truth table on 3f-48 (which has been copied onto the answer sheet for your convenience), state which row of the characteristic table was used to determine the output value for that row of the truth table. The first one has been filled in for you as an example.

2. Now it’s your turn to create your own truth tables. Draw the truth table for the characteristic table on 3f-50.

3. Same for the characteristic table on 3f-51.

4. Same for this characteristic table:

|  |  |  |
| --- | --- | --- |
| A | B | Q(t+1) |
| 0 | 0 | 1 |
| 0 | 1 | 0 |
| 1 | 0 | 1 |
| 1 | 1 | Q(t) |

Now consider this truth table:

|  |  |  |  |
| --- | --- | --- | --- |
| A | B | Q(t) | Q(t+1) |
| 0 | 0 | 0 | 1 |
| 0 | 0 | 1 | 1 |
| 0 | 1 | 0 | 0 |
| 0 | 1 | 1 | 0 |
| 1 | 0 | 0 | 0 |
| 1 | 0 | 1 | 1 |
| 1 | 1 | 0 | 1 |
| 1 | 1 | 1 | 0 |

Suppose you wanted to draw the corresponding characteristic table. For each pair of rows with the same values of A and B, you would need to come up with a formula for Q(t+1) in terms of Q(t) that works for each pair of rows. There are four possible answers: 0, 1, Q(t) and -Q(t).

Here is the answer to this sample problem:

|  |  |  |
| --- | --- | --- |
| A | B | Q(t+1) |
| 0 | 0 | 1 |
| 0 | 1 | 0 |
| 1 | 0 | Q(t) |
| 1 | 1 | -Q(t) |

5. Using the example above as a guide, draw the characteristic table for this truth table:

|  |  |  |  |
| --- | --- | --- | --- |
| A | B | Q(t) | Q(t+1) |
| 0 | 0 | 0 | 0 |
| 0 | 0 | 1 | 0 |
| 0 | 1 | 0 | 0 |
| 0 | 1 | 1 | 1 |
| 1 | 0 | 0 | 1 |
| 1 | 0 | 1 | 0 |
| 1 | 1 | 0 | 1 |
| 1 | 1 | 1 | 1 |

6. Here’s an easier one. There is only one variable, so your truth table will have only two rows. There are the same four possible answers for each cell.

|  |  |  |
| --- | --- | --- |
| A | Q(t) | Q(t+1) |
| 0 | 0 | 1 |
| 0 | 1 | 0 |
| 1 | 0 | 0 |
| 1 | 1 | 0 |

7. Here’s another one so you can get some more practice.

|  |  |  |
| --- | --- | --- |
| A | Q(t) | Q(t+1) |
| 0 | 0 | 1 |
| 0 | 1 | 1 |
| 1 | 0 | 0 |
| 1 | 1 | 1 |

Study the memory cells on slide 3g-62 (and the explanation on the preceding slides).

8. Suppose write enable = 1, S0 = 0, S1 = 1, In0 = 1, In1 = 0, In2 = 0.

a) When the clock ticks, which word of memory (if any) will be updated?

b) From top to bottom, what will the values in the bits of that word become?

c) What will the values of Out0, Out1, Out2 be?

Note: Here are the possible answers to question a): name of a word (word 0, word 1, word 2 or word 3), or “none”.

Here are the possible answers to question b): any bit combination, or “no change”.

Here are the possible answers to question c): any bit combination, or “bits currently in word n”, where n = 0, 1, 2 or 3.

Reminder: Remember to check the write enable bit!

9. Suppose write enable = 1, S0 = 1, S1 = 1, In0 = 0, In1 = 1, In2 = 1.

(same 3 questions as above)

10. Suppose write enable = 0, S0 = 1, S1 = 1, In0 = 0, In1 = 1, In2 = 1.

(same 3 questions as above)

11. Study the circuit in section 3h. Then fill in the table on the answer sheet showing the value of each of the outputs after the given number of clock ticks.

The first line is filled in to give you the initial values. The next two rows are filled in to give you some examples. Work those out yourself before you continue on your own.