ELEN 21, COEN 21: Logic Design Winter 2021

Homework 6

due Wednesday 17 February 2021

1. An 8 bit binary up counter has a regular clock input with a frequency of 64 MHz. (The time interval for one cycle of the clock signal is the reciprocal of the clock frequency.)
    a. Draw a timing diagram for the clock input and the three least significant bits of the counter for the first ten cycles of the input clock. Clearly show the time scale on your diagram.
    b. A circuit you are designing needs a 16 MHz clock and a 2 MHz clock, but your available input clock is 64MHz. How can the needed frequencies be obtained from your counter in part (a)? Explain.
    c. What is the lowest frequency clock signal you could obtain from your 8-bit counter?
    d. Could you obtain the needed clock frequencies in part (b) using a down counter instead of an up counter? Why or why not?

2. In a 4 bit synchronous free-running up-counter designed with T-type flip-flops, (see class notes or Figure 5.21) the toggle inputs are $T_0 = 1$, $T_1 = Q_0$, $T_2 = Q_1Q_0$, and $T_3 = Q_2Q_1Q_0$.
    a. Show how to modify this circuit to be a down counter by specifying the T inputs to each of the flip-flops to make the counter count down.
    b. Specify the T inputs to each flip-flop needed to make it count either up or down depending on input *U*, which would be 1 for counting up and 0 for counting down.

3. Figure 5.23 shows the circuit for a 4-bit synchronous up counter using D-type flip-flops.
    a. Show how to modify the D inputs of the flip-flops in this circuit to make it a 4-bit synchronous down counter.
    b. Show how to modify the circuit to allow both up and down counting with the direction controlled by input *U*, which would be 1 for counting up and 0 for counting down.

4. You need to design a circuit to count people entering a restricted museum exhibit that allows at most 7 visitors at one time. An input sensor provides an event signal which has a rising edge whenever a person enters the area. The count can be manually reset when the room has been cleared, and your circuit should produce an alarm signal if the count rises above 7 after people start entering the area. This alarm signal should stay high until the system is manually reset after the room has been cleared. You initially propose the use of a 4-bit up counter using T-type flip-flops as shown in Figure 5.21 and described in Problem 2. You would use Q3 as the alarm signal. However, your supervisor points out that if people continued to enter, when the count went over 15 the alarm signal would go low again. How would you modify the T inputs to keep Q3 high after 7 people have entered no matter how many additional people come into the area?