Engineering 5865 Digital Systems

Problem Set 3

0. Write a dataflow description for a 1-bit subtractor. Include a borrow input and a borrow output. Construct a 4-bit serial subtractor by using the 1-bit subtractor as the primitive component. Write the structural level description for the 4-bit subtractor. Write the testbench code which can be used to test the 4-bit subtractor.

1. Using the style of the serial adder that provided below, write a behavioral description for a serial subtractor. Indicate the changes you will make so that the testbench you have written can be to test this behavioral level serial subtractor.

```
ENTITY serial_adder IS
  PORT (a, b, start, clock : IN BIT; ready : OUT BIT;
           result : BUFFER BIT_VECTOR (7 DOWNTO 0));
END serial_adder;

ARCHITECTURE behavioral OF serial_adder IS
BEGIN
  PROCESS (clock)
  VARIABLE count : INTEGER := 8;
  VARIABLE sum, carry : BIT;
  BEGIN
    IF (clock = '0' AND clock'EVENT) THEN
      IF start = '1' THEN
        count := 0;
        carry := '0';
      ELSE
        IF count < 8 THEN
          count := count + 1;
          sum := a XOR b XOR carry;
          carry := (a AND b) OR (a AND carry) OR (b AND carry);
          result <= sum & result (7 DOWNTO 1);
        END IF;
      END IF;
    END IF;
    IF count = 8 THEN
      ready <= '1';
    ELSE
      ready <= '0';
    END IF;
  END PROCESS;
END behavioral;
```
2. The value of a signal called ‘SOUR’ should be assigned to another signal called ‘DEST’ so that there is a lag of 100 ns between the two. However, if signal SOUR experiences a change for a duration less than 85 ns, then signal DEST should not follow this change. Write the VHDL statement that will accomplish this.

3. Design a synchronous sequential circuit that detects overlapping 101 sequences on an input line. Sketch a state diagram corresponding to this detector. Employ negative edge triggered J-K flip-flops and any simple gates. Note that if the input sequence is 000101111001101010110, the output sequence must be 0000100000001010100. Design this as a Moore machine. Write the VHDL code.

4. Given the following description, show waveforms on x1, x2, and diff signals in a timing diagram. Explain the reason for the difference on x1 and x2.

   ARCHITECTURE comparing OF findout IS
   SIGNAL c, x1, x2, diff: BIT := '0';
   BEGIN
     c <= '0', '1' AFTER 60 NS, '0' AFTER 120 NS;
     x1 <= '1' AFTER 6 NS WHEN c'EVENT ELSE x1;
     x2 <= '1' AFTER 6 NS WHEN NOT c'STABLE ELSE x2;
     diff <= x1 XOR x2;
   END comparing;

5. Use a process statement to develop a behavioral description for a toggle flip-flop (t-ff). The t_ff has a single t input and two q and qb outputs. After the rising edge of the t input, the two outputs will be complemented. The q output has a low-to-high propagation delay of q_tplh and a high-to-low propagation delay of q_tphl. The qb output has a low-to-high propagation delay of qb_tplh and a high-to-low propagation delay of qb_tphl. Pass the propagation delays as generic parameters and use them in your behavioral description. Write the complete description using the entity declared below:

   ENTITY t_ff IS
     GENERIC (q_tplh, q_tphl, qb_tplh, qb_tphl : TIME);
     PORT (t : IN BIT; q, qb : OUT BIT);
   END t_ff;