ORDRE DES INGÉNIEURS DU QUÉBEC

MAY 2016 SESSION

Open-book examination
Calculators : only authorized models
Duration : 3 hours

14-IF-A2 Digital System Design

1) Design a combinational circuit to convert a 3-bit input value, X_0, X_1, X_2 into a 3-bit output value Y_0, Y_1, Y_2 with the following translation table:

X_0, X_1, X_2	Y_0, Y_1, Y_2
000 (0_{10})	000
001 (1_{10})	001
010 (2_{10})	011
011 (3_{10})	010
100 (4_{10})	110
101 (5_{10})	111
110 (6_{10})	101
111 (7_{10})	100

   a) Draw K Maps of the outputs Y_0, Y_1, Y_2 **(10 points)**
   b) Design the circuit using elementary gates **(10 points)**

2) Design a synchronous circuit with 3 outputs, Y_0, Y_1 and Y_2, with the following behavior for each clock pulse:
   If the input X = 0, add 011 (3_{10}) to the binary value represented by Y_0, Y_1 and Y_2 and if the input X = 1, add 101 (5_{10}) to the binary value represented by Y_0, Y_1 and Y_2.
   The initial value of Y_0, Y_1 and Y_2 can be any value between 000 (0_{10}) and 111 (7_{10}) and is setup with a load mechanism outside the scope of this problem.
   a) Draw the full state diagram of this circuit **(10 points)**
   b) Design the circuit with J-K flip-flop(s) **(20 points)**
   c) Propose an alternate design with standard MSI devices like register latches, counters, adders (and also some gates) etc… **(10 points)**

3) We want to design a synchronous serial communication system to be used between two computers. The data carried by the system are 8-bit bytes that are sent serially one bit at a time synchronized by a clock provided by the sender. From the computer point of view, the data are loaded in parallel at the sender side and are read in parallel at the receiver side.
   a) Identify the different signals involved in the communication link **(5 points)**
   b) Is a byte synchronization signal mandatory? Why? **(10 points)**
   c) Design the circuit with standard MSI devices **(10 points)**
   d) Propose an interface between the computer and the communication system at each end, sender and receiver. Give the different signals involved in such an interface and explain for each their function **(10 points)**
   e) Can you identify a standard serial protocol that could be compared with this serial communication system? **(5 points)**