Problem #1 (3 types)

Type1: last two digits in the student ID number % 3 == 0 (202012345 => 45%3 = 0)

(20 pts) A sequential circuit with three D-FF's has the Boolean expressions as below,

$D_1=Q_2Q_3' + XQ_1'$ $D_2=Q_3+X'Q_2$ $D_3=Q_2' + X$ $Z=XQ_2' + X'Q_2$

Where D_1, D_2, D_3 are the inputs of D-FF's, Q_1, Q_2, Q_3 are the outputs of D-FF's, X is an input and Z is an output of the circuit. Draw the complete state table and state graph of the circuit.

Type2: last two digits in the student ID number % 3 == 1 (202012346 => 46%3 = 1)

(20 pts) A sequential circuit with three D-FF's has the Boolean expressions as below,

$D_1=Q_3+XQ_2$ $D_2=Q_2Q_3' + XQ_1'$ $D_3=Q_2' + X$ $Z=X'Q_2' + X'Q_1$

Type3: last two digits in the student ID number % 3 == 2 (202012347 => 47%3 = 2)

(20 pts) A sequential circuit with three D-FF's has the Boolean expressions as below,

$D_1=Q_2' + X$ $D_2=Q_3+X'Q_2'$ $D_3=Q_2Q_3' + XQ_1'$ $Z=XQ_3 + X'Q_2$

Problem #2 (2 types)

Type1: last digit in the student ID number % 2 == 1 (202012345 => 45%2 = 1)

(40 points) Design the 4-bit decade counter for the excess-3 code of decimal digits, 0011, 0100, 0101, 0110, 0111, 1000, 1001, 1010, 1011, 1100, 0011, ….
Find the minimum sum of product forms for T-FFs.

Type2: last digit in the student ID number % 2 == 0 (202012346 => 46%2 = 0)

(40 points) Design the 4-bit decade counter for the excess-3 code of decimal digits, 0011, 0100, 0101, 0110, 0111, 1000, 1001, 1010, 1011, 1100, 0011, ….
Find the minimum sum of product forms for J-K-FFs

Problem #3 (2 types)

Type1: last digit in the student ID number : 0, 1, 2, 3, 4 (202012340, 202012341,…)

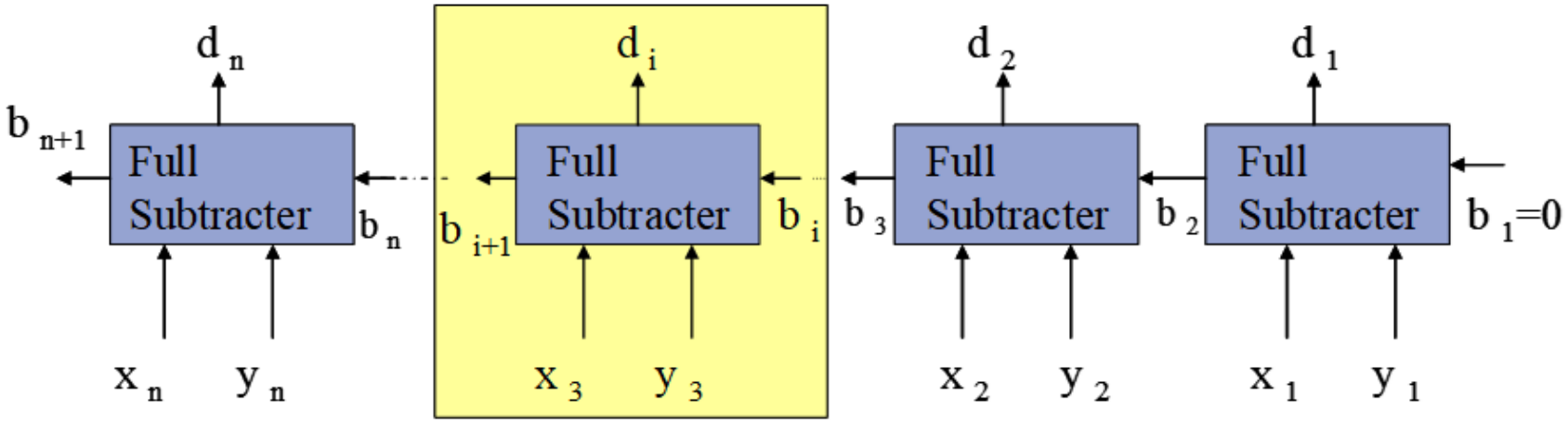
(20 pts) Convert a D Flip-Flop to a J-K Flip-Flop (Make a J-K FF using a D FF and some gates) by adding external gates. You should write the Boolean expression for the inputs of FFs.

Type2: last digit in the student ID number : 5, 6, 7, 8, 9 (202012345 202012348, …)

(20 pts) Convert a T Flip-Flop to a J-K Flip-Flop (Make a J-K FF using a D FF and some gates) by adding external gates. You should write the Boolean expression for the inputs of FFs.

Problem #4 (1 type)

(30 points) Design a 1-bit binary full subtractor as shown below,



1) (10pts) Find truth table for inputs and outputs.

$$input = \{x_i, y_i, b_i\}, \quad output = d_i, b_{i+1}$$

2) (5pts) Find the minimum sum-of-product expressions for the outputs.

3) (5pts) Draw the circuits of b_{i+1} using ROM.

4) (5pts) Draw the minimum circuits of b_{i+1} using PLA.

5) (5pts) Draw the circuits of output d_i using Multiplexers.

Problem #5 (1 type)

(50 pts) Design a decade 4-bit counter of the sequence: 0000, 1001, 1000, 0111, 0110, 0101, 0100, 0011, 0010, 0001, 0000, …

a) (40 pts) Use J-K Flip-Flops (For convenient checkout, set states as ABCD=0000, 0001, 0010, ….). Write the Boolean expression for the inputs of FFs as the minimum sum of product forms.

b) (10 pts) Draw a complete state diagram for the designed counter showing what happens when the counter is started in each of the unused states. (You should draw 16 states and their connections)