# CS120B – Homework #1

Summer 2 2003. Professor Hwang

Given July 31, 2003. Due August 5, 2003 at the beginning of class.

No late homework accepted.

Your work must be completely typeset with a word processor. Circuit diagrams can be drawn using any drawing program or by hand but it must be very neat. Handwritten works will **NOT** be accepted. (12 points total)

1. Since we can use any of the four different types of flip-flops to synthesize the same functional circuit, we should, therefore be able to use one type of flip-flop to implement the functional operation of another type of flip-flop. Use the JK flip-flop to implement the operations of the SR, D, and T flip-flops. In other words, synthesize the circuit for the SR, D and T flip-flops using only JK flip-flops. You need to have three different circuits, one for each type of the three flip-flops. (3)

***Answer***

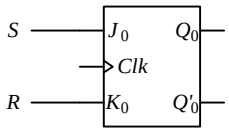
SR next-state table:

| | SR= | | | |
|---|---|---|---|---|
| $Q_0$ | 00 | 01 | 11 | 10 |
| 0 | 0 | 0 | × | 1 |
| 1 | 1 | 0 | × | 1 |

SR implementation table using JK ff:

| | SR= | | | |
|---|---|---|---|---|
| $Q_0$ | 00 | 01 | 11 | 10 |
| 0 | 0× | 0× | ×× | 1× |
| 1 | ×0 | ×1 | ×× | ×0 |

$J = S$
$K = R$



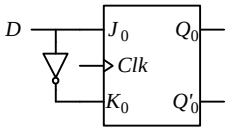

D next-state table:

| | D= | |
|---|---|---|
| $Q_0$ | 0 | 1 |
| 0 | 0 | 1 |
| 1 | 0 | 1 |

D implementation table using JK ff:

| | D= | |
|---|---|---|
| $Q_0$ | 0 | 1 |
| 0 | 0× | 1× |
| 1 | ×1 | ×0 |

$J = D$
$K = D'$



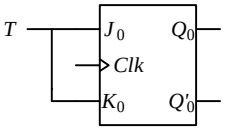

T next-state table:

T implementation table using JK ff:

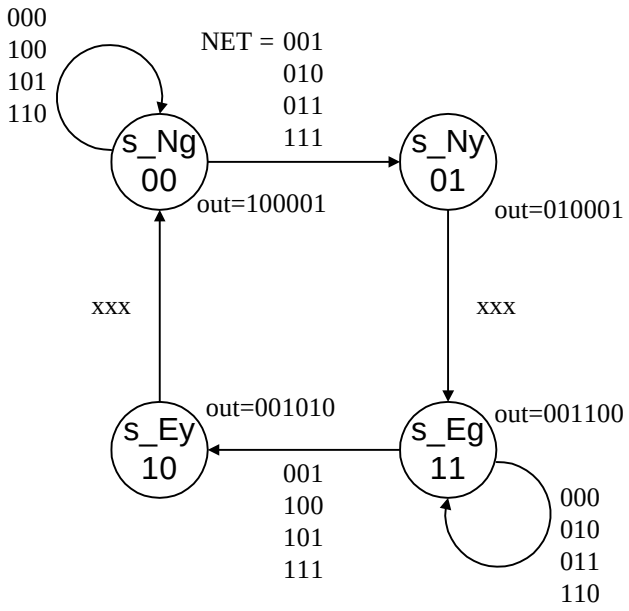
| | T= | |
|---|---|---|
| $Q_0$ | 0 | 1 |
| 0 | 0 | 1 |
| 1 | 1 | 0 |

| | T= | |
|---|---|---|
| $Q_0$ | 0 | 1 |
| 0 | 0× | 1× |
| 1 | ×0 | ×1 |

$J = T$
$K = T$




2. Synthesize a FSM for the following state diagram using SR flip-flops. The input bits are N, E, and T. The output bits are NSg, NSy, NSr, EWg, EWy, and EWr. (3)




***Answer***

Next-state table:

| Current State $Q_1\ Q_0$ | Next State $Q_{1next}\ Q_{0next}$ | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | NET= | | | | | | | |
| | 000 | 001 | 010 | 011 | 100 | 101 | 110 | 111 |
| 00 | 00 | 01 | 01 | 01 | 00 | 00 | 00 | 01 |
| 01 | 11 | 11 | 11 | 11 | 11 | 11 | 11 | 11 |
| 11 | 11 | 10 | 11 | 11 | 10 | 10 | 11 | 10 |
| 10 | 00 | 00 | 00 | 00 | 00 | 00 | 00 | 00 |

Output table:

| Current State $Q_1\ Q_0$ | Output *NSg, NSy, NSr, EWg, EWy, EWr* |
|---|---|
| 00 | 100001 |
| 01 | 010001 |
| 11 | 001100 |
| 10 | 001010 |

$NSg = Q_1'Q_0'$
$NSy = Q_1'Q_0$
$NSr = Q_1$
$EWg = Q_1Q_0$
$EWy = Q_1Q_0'$
$EWr = Q_1'$

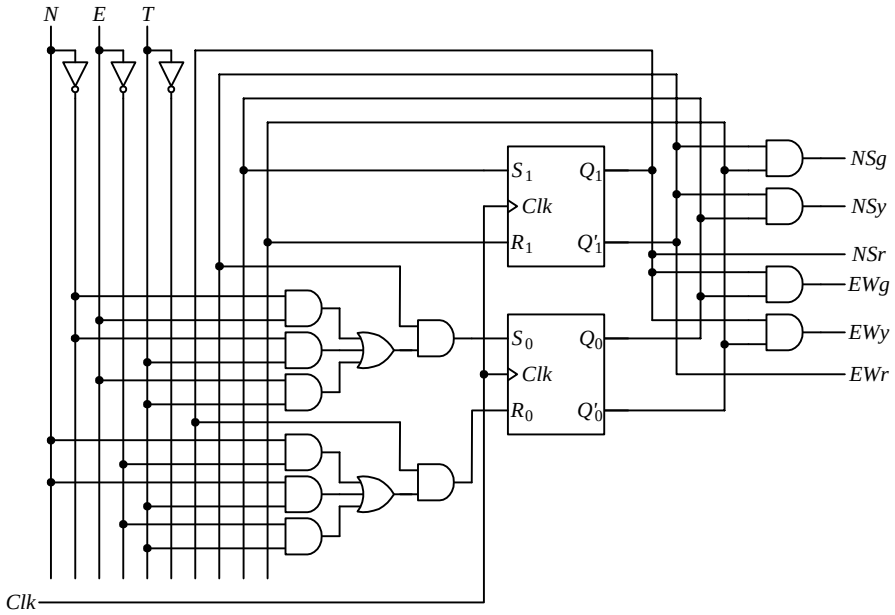
Implementation table:

| Current State $Q_1\ Q_0$ | Implementation $S_1\ R_1\ S_0\ R_0$ | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | NET= | | | | | | | |
| | 000 | 001 | 010 | 011 | 100 | 101 | 110 | 111 |
| 00 | 0×0× | 0×10 | 0×10 | 0×10 | 0×0× | 0×0× | 0×0× | 0×10 |
| 01 | 10×0 | 10×0 | 10×0 | 10×0 | 10×0 | 10×0 | 10×0 | 10×0 |
| 11 | ×0×0 | ×001 | ×0×0 | ×0×0 | ×001 | ×001 | ×0×0 | ×001 |
| 10 | 010× | 010× | 010× | 010× | 010× | 010× | 010× | 010× |

Excitation equations:

$S_1 = Q_0$
$R_1 = Q_0'$
$S_0 = Q_1' (N' E + N' T + ET)$
$R_0 = Q_1 (NE' + NT + E' T)$

Circuit:




3. Repeat question 2 but use T flip-flops. (3)

***Answer***

Implementation table:

| Current State $Q_1\ Q_0$ | Implementation $T_1\ T_0$ NET= | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 000 | 001 | 010 | 011 | 100 | 101 | 110 | 111 |
| 00 | 00 | 01 | 01 | 01 | 00 | 00 | 00 | 01 |
| 01 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 |
| 11 | 00 | 01 | 00 | 00 | 01 | 01 | 00 | 01 |
| 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 |

Excitation equations:

$T_1 = Q_1 \oplus Q_0$

$T_0 = Q_1'Q_0'\,(N'\,T + N'\,E + ET) + Q_1Q_0(NE' + NT + E'\,T)$

4. Repeat question 2 but use D flip-flops. (3)

***Answer***

Implementation table:

| Current State $Q_1\ Q_0$ | Implementation $D_1\ D_0$ | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | NET= | | | | | | | |
| | 000 | 001 | 010 | 011 | 100 | 101 | 110 | 111 |
| 00 | 00 | 01 | 01 | 01 | 00 | 00 | 00 | 01 |
| 01 | 11 | 11 | 11 | 11 | 11 | 11 | 11 | 11 |
| 11 | 11 | 10 | 11 | 11 | 10 | 10 | 11 | 10 |
| 10 | 00 | 00 | 00 | 00 | 00 | 00 | 00 | 00 |

Excitation equations:

$D_1 = Q_0$

$D_0 = Q_1'Q_0 + Q_1' (N' T + N' E + ET) + Q_1 (N' T ' + N' E + ET ' )$