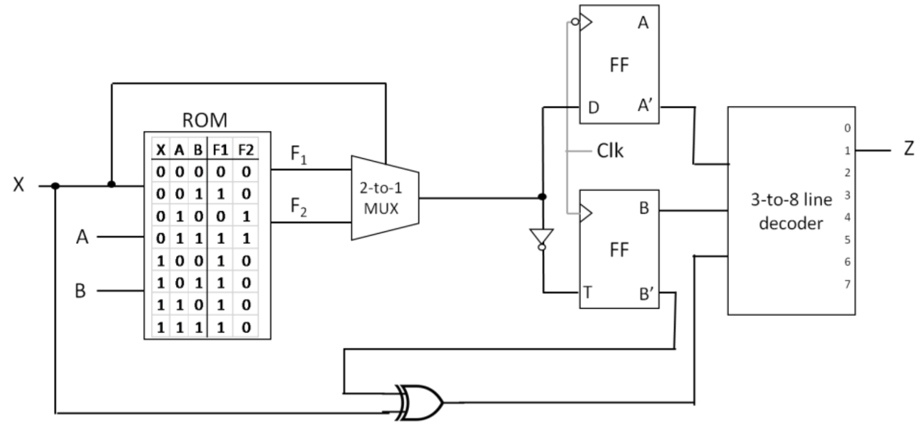



**Fall 2016 BSM 203 Logic Circuits Final Exam Solutions**

**1.** For the circuit given in the work sheet, answer the following questions.

a. Derive the FF input equations (D, T), FF next state equations ($A^+$ and $B^+$), and output equation (Z).

$D = X'F_1 + XF_2 = X'(X + B) + X(X'A) = X'B$ $\quad T = D' = X + B'$

$A^+ = D = X'B$ $\quad B^+ = T'B + TB' = (X'B)B + (X + B')B' = X'B + \cancel{XB'} + B' = X'\cancel{B} + B' = X' + B'$

$Z = m_1 = AB'(X'B' + XB) = X'AB'$

b. Is this a Mealy Machine or Moore Machine? Explain your answerin one sentence below.

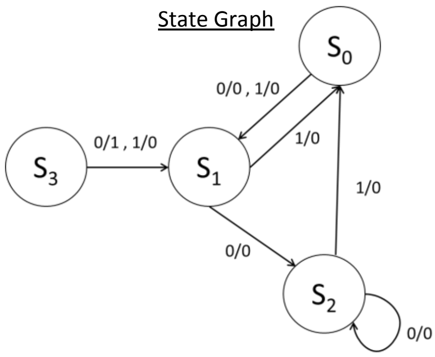
This is a Mealy machine, because output depends on both the input and FF outputs.

c. Construct the state transition table, next state table, and state graph below.

| Next-State Table | | | | |
|---|---|---|---|---|
| AB | $A^+B^+$ | | Z | |
| | X = 0 | X = 1 | X =0 | X= 1 |
| 00 | 01 | 01 | 0 | 0 |
| 01 | 11 | 00 | 0 | 0 |
| 11 | 11 | 00 | 0 | 0 |
| 10 | 01 | 01 | 1 | 0 |

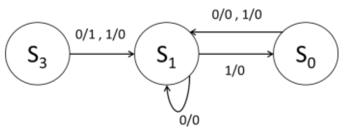
| State-Transition Table | | | | |
|---|---|---|---|---|
| Present | Next | | Output | |
| | X = 0 | X = 1 | X = 0 | X = 1 |
| $S_0$ | $S_1$ | $S_1$ | 0 | 0 |
| $S_1$ | $S_2$ | $S_0$ | 0 | 0 |
| $S_2$ | $S_2$ | $S_0$ | 0 | 0 |
| $S_3$ | $S_1$ | $S_1$ | 1 | 0 |

State Graph

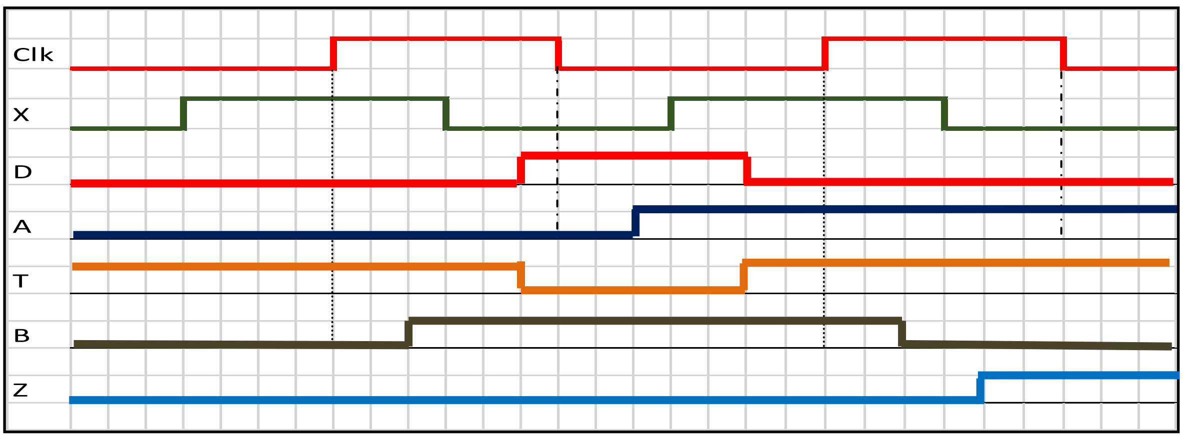



As you may notice, $S_1$ and $S_2$ are equivalent states. Thus we can remove $S_2$, then the state graph is below:

Whoever notice this will get 5 bonus points.



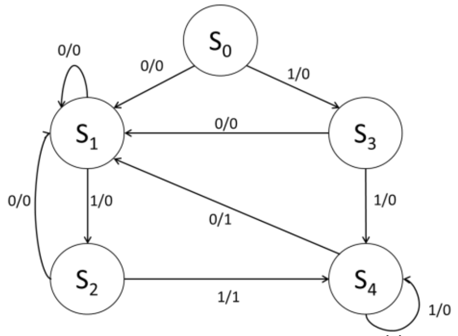

d. Complete the timing chart shown below for the circuit for an input sequence X as shown in the chart below and the clock period 12ns. Assume that T-FF is rising-edge and D-flip flop is falling-edge triggered, that initially A = B= 0, and that X changes midway between the rising and falling clock edges. The delays in ROM, decoder, and MUXare 1 ns for each and delay in each FF is 2 ns. The delay in XOR gate is negligible.



**2.** Please indicate which question you solved (2.1 or 2.2):**2.1**(This is basically a sequence detector for either 011 or 110.

## For Mealy Machine

Step 1: Derive the state graph




Step 2: Construct state-transition table

| State-Transition Table | | | | |
|---|---|---|---|---|
| Present | Next State | | Z | |
| | X = 0 | X = 1 | X = 0 | X =1 |
| $S_0$ | $S_1$ | $S_3$ | 0 | 0 |
| $S_1$ | $S_1$ | $S_2$ | 0 | 0 |
| $S_2$ | $S_1$ | $S_4$ | 0 | 1 |
| $S_3$ | $S_1$ | $S_4$ | 0 | 0 |
| $S_4$ | $S_1$ | $S_4$ | 1 | 0 |

Step 3: Decide how many FFs required and construct next-state table

| Next-State Table | | | | |
|---|---|---|---|---|
| ABC | $A^+B^+C^+$ | | Z | |
| | X = 0 | X = 1 | X = 0 | X =1 |
| 000 | 001 | 011 | 0 | 0 |
| 001 | 001 | 010 | 0 | 0 |
| 010 | 001 | 100 | 0 | 1 |
| 011 | 001 | 100 | 0 | 0 |
| 100 | 001 | 100 | 1 | 0 |

Step 4: Decide the type of FF you use and derive the FF input equations and output equation.

$Z = X'A + XBC'$

For D Flip-Flop: $D_A = X(A + B)$; $D_B = XA'B'$; $D_C = X' + A'B'C'$

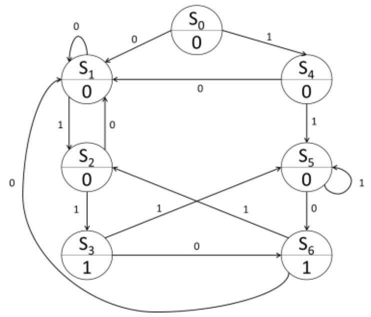
For T Flip-Flop: $T_A = X'A + XB$; $T_B = A+(X+B)$; $T_C = (X\oplus C)'+A'B'C'$

For J-K FF: $J_A = XB$ $K_A = X'$ (or B) $J_B = XA'$ $K_B = 1$ $J_C = X' + B'$ $K_C = 1$

Surely in answers, just equations are not sufficient, Karnaugh maps should be here as well.

## For Moore Machine

Step 1: Derive the state graph




Step 2: Construct state-transition table

| State-Transition Table | | | |
|---|---|---|---|
| Present | Next State | | Z |
| | X = 0 | X = 1 | |
| $S_0$ | $S_1$ | $S_4$ | 0 |
| $S_1$ | $S_1$ | $S_2$ | 0 |
| $S_2$ | $S_1$ | $S_3$ | 0 |
| $S_3$ | $S_6$ | $S_5$ | 1 |
| $S_4$ | $S_1$ | $S_5$ | 0 |
| $S_5$ | $S_6$ | $S_5$ | 0 |
| $S_6$ | $S_1$ | $S_2$ | 1 |

Step 3: Decide how many FFs required and construct next-state table

| Next-State Table | | | |
|---|---|---|---|
| ABC | $A^+B^+C^+$ | | Z |
| | X = 0 | X = 1 | |
| 000 | 001 | 100 | 0 |
| 001 | 001 | 010 | 0 |
| 010 | 001 | 011 | 0 |
| 011 | 110 | 101 | 1 |
| 100 | 001 | 101 | 0 |
| 101 | 110 | 101 | 0 |
| 110 | 001 | 010 | 1 |

Step 4: Decide the type of FF you use and derive the FF input equations and output equation.

$Z = A'BC + ABC' = B(A\oplus C)$

For D Flip-Flop: $D_A = C(A + B) + XB'C'$; $D_B = X(BC' + A'B'C) + X'C(A +B)$;
$D_C = X'(C' + A'B') + A(X\oplus B)$

For T Flip-Flop: $T_A = B(A + C) + C'(XA'B' + X'A)$; $T_B = C(X\oplus A)+X'BC$;
$T_C = X'(A + C) + C'(A\oplus B)+ XA'B'C$

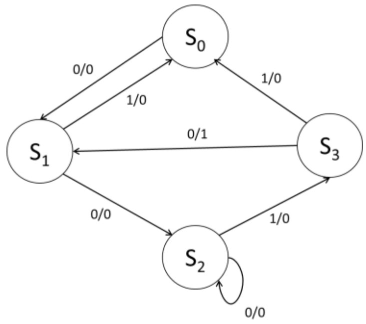
For J-K FF: $J_A = BC + XB'C'$ $K_A = B + X'C'$ $J_B = C(X\oplus A)$ $K_B = (X\oplus C)'$
$J_C = X' + (A\oplus B)$ $K_C = X \oplus (A + B)$

Surely in answers, just equations are not sufficient, Karnaugh maps should be here as well.

**2.** Please indicate which question you solved (2.1 or 2.2): **2.2**sequence detector for 0010.

**For Mealy Machine**

Step 1: Derive the state graph




Step 2: Construct state-transition table

| State-Transition Table | | | | |
|---|---|---|---|---|
| Present | Next State | | Z | |
| | X = 0 | X = 1 | X = 0 | X =1 |
| $S_0$ | $S_1$ | $S_0$ | 0 | 0 |
| $S_1$ | $S_2$ | $S_0$ | 0 | 0 |
| $S_2$ | $S_2$ | $S_3$ | 0 | 0 |
| $S_3$ | $S_1$ | $S_0$ | 1 | 0 |

Step 3: Decide how many FFs required and construct next-state table

| Next-State Table | | | | |
|---|---|---|---|---|
| AB | $A^+B^+$ | | Z | |
| | X = 0 | X = 1 | X = 0 | X =1 |
| 00 | 01 | 00 | 0 | 0 |
| 01 | 11 | 00 | 0 | 0 |
| 11 | 11 | 10 | 0 | 0 |
| 10 | 10 | 00 | 1 | 0 |

Step 4: Decide the type of FF you use and derive the FF input equations and output equation.

$Z = X'AB'$

For D Flip-Flop: $D_A = B(X' + A)$;    $D_B = X'$;

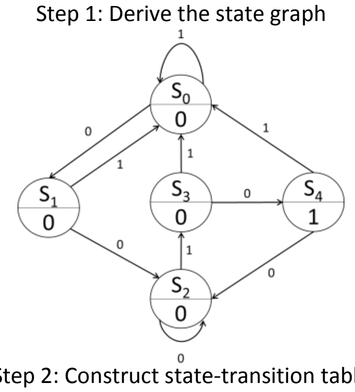
For T Flip-Flop: $T_A = AB' + X'A'B$;    $T_B = (X \oplus B)'$;

For J-K FF: $J_A = X'B$   $K_A = B'$   $J_B = X'$      $K_B = X$

Surely in answers, just equations are not sufficient, Karnaugh maps should be here as well.

**For Moore Machine**

Step 1: Derive the state graph




Step 2: Construct state-transition table

| State-Transition Table | | | |
|---|---|---|---|
| Present | Next State | | Z |
| | X = 0 | X = 1 | |
| $S_0$ | $S_1$ | $S_0$ | 0 |
| $S_1$ | $S_2$ | $S_0$ | 0 |
| $S_2$ | $S_2$ | $S_3$ | 0 |
| $S_3$ | $S_4$ | $S_0$ | 0 |
| $S_4$ | $S_2$ | $S_0$ | 1 |

Step 3: Decide how many FFs required and construct next-state table

| Next-State Table | | | |
|---|---|---|---|
| ABC | $A^+B^+C^+$ | | Z |
| | X = 0 | X = 1 | |
| 000 | 001 | 000 | 0 |
| 001 | 010 | 000 | 0 |
| 010 | 010 | 011 | 0 |
| 011 | 100 | 000 | 0 |
| 100 | 010 | 000 | 1 |

Step 4: Decide the type of FF you use and derive the FF input equations and output equation.

$Z = AB'C'$

For D Flip-Flop: $D_A = X'BC$;    $D_B = BC' + X'(A + B'C)$;
$D_C = C'(X'A'B' + XB)$

For T Flip-Flop: $T_A = A + X'BC$  $T_B = BC + X'(A + B)$
$T_C = C + XB + X'A'B'$

For J-K FF: $J_A = X'BC$   $K_A = 1$   $J_B = X'(A + C)$      $K_B = C$
$J_C = X'A'B' + XB$      $K_C = 1$

Surely in answers, just equations are not sufficient, Karnaugh maps should be here as well.