***Binary Up-Down counter***

***Each labs worth 10 points***

***All lab work must be initiated during the lab hour and be completed during the lab hour.  
Only when additional time is required, the student may show the lab instructor his uncompleted work during the lab, then complete the lab work in the following day for 2 points off.***

    1.     Design a sequential circuit has two T flip-flops A and B, two inputs E and x. If E=0, the circuit remains in the same state regardless of the value of the x. When E=1 and x=1, the circuit goes through the state transitions from 00 to 01 to 10 to 11 back to 00, and repeats. When E=1 and x=0, the circuit goes through the state transitions from 00 to 11 to 10 to 01 back to 00, and repeats. Draw the state diagram and find out the sate equation.

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| x | E | A(t) | B(t) | TA | TB | A(t+1) | B(t+1) |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 |
| 0 | 0 | 1 | 0 | 0 | 0 | 1 | 0 |
| 0 | 0 | 1 | 1 | 0 | 0 | 1 | 1 |
| 0 | 1 | 0 | 0 | 1 | 1 | 1 | 1 |
| 0 | 1 | 0 | 1 | 0 | 1 | 0 | 0 |
| 0 | 1 | 1 | 0 | 1 | 1 | 0 | 1 |
| 0 | 1 | 1 | 1 | 0 | 1 | 1 | 0 |
| 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 1 | 0 | 0 | 1 | 0 | 0 | 0 | 1 |
| 1 | 0 | 1 | 0 | 0 | 0 | 1 | 0 |
| 1 | 0 | 1 | 1 | 0 | 0 | 1 | 1 |
| 1 | 1 | 0 | 0 | 0 | 1 | 0 | 1 |
| 1 | 1 | 0 | 1 | 1 | 1 | 1 | 0 |
| 1 | 1 | 1 | 0 | 0 | 1 | 1 | 1 |
| 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 |
|  |  |  |  |  |  |  |  |

A(t+1) = TA⊕A(t)

TA = x’EB’ + xEB

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| xE | AB |  |  |  |
|  | 00 | 01 | 11 | 10 |
| 00 | 0 | 0 | 0 | 0 |
| 01 | 1 | 0 | 0 | 1 |
| 11 | 0 | 1 | 1 | 0 |
| 10 | 0 | 0 | 0 | 0 |

B(t+1) = TB⊕B(t)

TB = E

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| xE | AB |  |  |  |
|  | 00 | 01 | 11 | 10 |
| 00 | 0 | 0 | 0 | 0 |
| 01 | 1 | 1 | 1 | 1 |
| 11 | 1 | 1 | 1 | 1 |
| 10 | 0 | 0 | 0 | 0 |

11

00,10

11

11

00,10

00,10

00,10

11

01

01

01

01