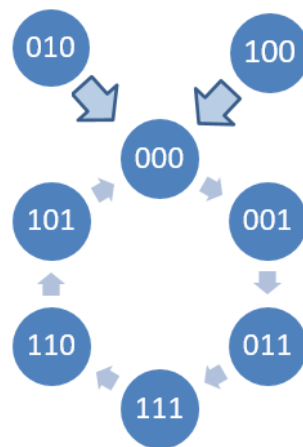


Circuit Design: Display a number sequence

Design a six state skip counter using either JK or D Flip-Flops:

- The number of flip flops required is 3 which gives 8 unique states (0 through 7).
- Use any six unique digits of your birthday to determine the states.
- For example, if you were born on January 3, 1998 then your birthday can be represented as: 01/03/1998 so the digits of your birthday are: 0, 1, 0, 3, 1, 9, 9, 8.
- Do not use any digit more than once. Do not use the digits 8 or 9. Pick other digits.
- For example the modified sequence using the digits above might be: 0, 1, 3, 7, 6, 5
- Unused states should go to your initial state.
- Using the Flip Flop Excitation Table on page 3 or 4, develop the Transition State Table.
- Create and reduce the Karnaugh maps from the Transition State Table and create the circuit using Multisim.
- You must demonstrate a working circuit to me. Your report should describe the design process and must include the Multisim file along with the completed Transition State Table and Karnaugh maps.
- **Note that no students should be using the same sequence in their counters.**
- Draw the State Diagram showing arrows between states. Unused states should go to your initial state. Note that they are not to be used as Don't Care States.
- An example of how to use the J-K Flip Flop Excitation Table to create the Transition State Table is shown on page 4.



State Table for the Sequence 0,1,3,7,6,5

Template For D Flip-flops:

| <u>From Q_n</u> | | <u>To Q_{n+1}</u> | <u>D</u> | <u>Comment</u> |
|------------------------------|---|--------------------------------|----------|----------------|
| X | → | 0 | 0 | Follow D |
| X | → | 1 | 1 | Follow D |

State Table

| | <u>Current State</u> | | | | <u>Next State</u> | | | | | |
|----|----------------------|-------|-------|-----|-------------------|-------|-------|-------|-------|-------|
| MT | Q_2 | Q_1 | Q_0 | CLK | Q_2 | Q_1 | Q_0 | D_2 | D_1 | D_0 |
| 0 | 0 | 0 | 0 | ↑ | | | | | | |
| 1 | 0 | 0 | 1 | ↑ | | | | | | |
| 2 | 0 | 1 | 0 | ↑ | | | | | | |
| 3 | 0 | 1 | 1 | ↑ | | | | | | |
| 4 | 1 | 0 | 0 | ↑ | | | | | | |
| 5 | 1 | 0 | 1 | ↑ | | | | | | |
| 6 | 1 | 1 | 0 | ↑ | | | | | | |
| 7 | 1 | 1 | 1 | ↑ | | | | | | |

Example For Sequence 0-1-3-7-6-5

For JK Flip-flops (Excitation Table):

| <u>From Q_n</u> | | <u>To Q_{n+1}</u> | <u>J</u> | <u>K</u> | <u>Comment</u> |
|------------------------------|---|--------------------------------|----------|----------|-----------------|
| 0 | → | 0 | 0 | X | N/C or Reset |
| 0 | → | 1 | 1 | X | Toggle or Set |
| 1 | → | 0 | X | 1 | Toggle or Reset |
| 1 | → | 1 | X | 0 | N/C or Set |

Transition Table For Sequence 0-1-3-7-6-5

| | Current State | | | | Next State | | | | | | | | |
|----|----------------|----------------|----------------|-----|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|
| MT | Q ₂ | Q ₁ | Q ₀ | CLK | Q ₂ | Q ₁ | Q ₀ | J ₂ | K ₂ | J ₁ | K ₁ | J ₀ | K ₀ |
| 0 | 0 | 0 | 0 | ↓ | 0 | 0 | 1 | 0 | X | 0 | X | 1 | X |
| 1 | 0 | 0 | 1 | ↓ | 0 | 1 | 1 | 0 | X | 1 | X | X | 0 |
| 2 | 0 | 1 | 0 | ↓ | 0 | 0 | 0 | 0 | X | X | 1 | 0 | X |
| 3 | 0 | 1 | 1 | ↓ | 1 | 1 | 1 | 1 | X | X | 0 | X | 0 |
| 4 | 1 | 0 | 0 | ↓ | 0 | 0 | 0 | X | 1 | 0 | X | 0 | X |
| 5 | 1 | 0 | 1 | ↓ | 0 | 0 | 0 | X | 1 | 0 | X | X | 1 |
| 6 | 1 | 1 | 0 | ↓ | 1 | 0 | 1 | X | 0 | X | 1 | 1 | X |
| 7 | 1 | 1 | 1 | ↓ | 1 | 1 | 0 | X | 0 | X | 0 | X | 1 |

For Example in Minterm 0, Q₂ goes from a Current State of **0** to a Next State of **0** which results in **J₂=0, K₂=X**

Q₁ goes from a Current State of **0** to a Next State of **0** which results in **J₁=0, K₁=X**

Q₀ goes from a Current State of **0** to a Next State of **1** which results in **J₀=1, K₀=X**

Now complete the Karnaugh Maps for J₀, K₀, J₁, K₁, J₂, K₂

Note that both State 2 and State 4 are returned to the initial state, which in this example is zero. This is done in case the flip flops power up at State 2 or 4 or if a power spike results in the counter at State 2 or 4.

Karnaugh Maps Example For Sequence 0-1-3-7-6-5

Karnaugh Map Worksheets (A=Q0, B=Q1, C=Q2)

| | \bar{A} | A | | \bar{A} |
|-----------|--------------------------------|--------------------------|--------------------|--------------------------|
| \bar{C} | $\bar{C}\bar{B}\bar{A}=0$ 1 | $\bar{C}\bar{B}A=1$ X | $\bar{C}BA=3$ X | $\bar{C}B\bar{A}=2$ 0 |
| C | $C\bar{B}\bar{A}=4$ 0 | $C\bar{B}A=5$ X | $CBA=7$ X | $CB\bar{A}=6$ 1 |
| | \bar{B} | | B | |

$$J_A = BC + \bar{B}\bar{C} \text{ (note could use XNOR)}$$

| | \bar{A} | A | | \bar{A} |
|-----------|--------------------------------|--------------------------|--------------------|--------------------------|
| \bar{C} | $\bar{C}\bar{B}\bar{A}=0$ X | $\bar{C}\bar{B}A=1$ 0 | $\bar{C}BA=3$ 0 | $\bar{C}B\bar{A}=2$ X |
| C | $C\bar{B}\bar{A}=4$ X | $C\bar{B}A=5$ 1 | $CBA=7$ 1 | $CB\bar{A}=6$ X |
| | \bar{B} | | B | |

$$K_A = C$$

| | \bar{A} | A | | \bar{A} |
|-----------|--------------------------------|--------------------------|--------------------|--------------------------|
| \bar{C} | $\bar{C}\bar{B}\bar{A}=0$ 0 | $\bar{C}\bar{B}A=1$ 1 | $\bar{C}BA=3$ X | $\bar{C}B\bar{A}=2$ X |
| C | $C\bar{B}\bar{A}=4$ 0 | $C\bar{B}A=5$ 0 | $CBA=7$ X | $CB\bar{A}=6$ X |
| | \bar{B} | | B | |

$$J_B = A\bar{C}$$

| | \bar{A} | A | | \bar{A} |
|-----------|--------------------------------|--------------------------|--------------------|--------------------------|
| \bar{C} | $\bar{C}\bar{B}\bar{A}=0$ X | $\bar{C}\bar{B}A=1$ X | $\bar{C}BA=3$ 0 | $\bar{C}B\bar{A}=2$ 1 |
| C | $C\bar{B}\bar{A}=4$ X | $C\bar{B}A=5$ X | $CBA=7$ 0 | $CB\bar{A}=6$ 1 |
| | \bar{B} | | B | |

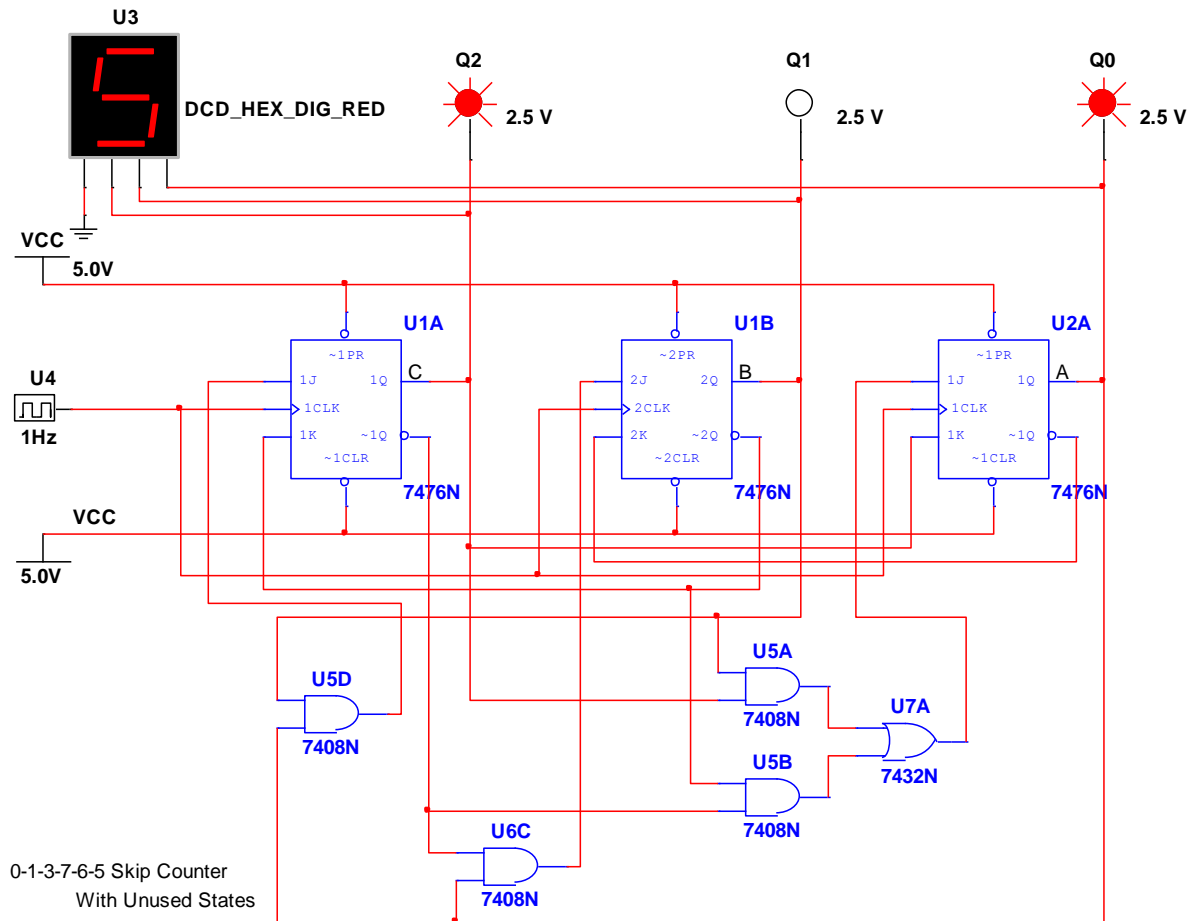
$$K_B = \bar{A}$$

| | \bar{A} | A | | \bar{A} |
|-----------|--------------------------------|--------------------------|--------------------|--------------------------|
| \bar{C} | $\bar{C}\bar{B}\bar{A}=0$ 0 | $\bar{C}\bar{B}A=1$ 0 | $\bar{C}BA=3$ 1 | $\bar{C}B\bar{A}=2$ 0 |
| C | $C\bar{B}\bar{A}=4$ X | $C\bar{B}A=5$ X | $CBA=7$ X | $CB\bar{A}=6$ X |
| | \bar{B} | | B | |

$$J_C = AB$$

| | \bar{A} | A | | \bar{A} |
|-----------|--------------------------------|--------------------------|--------------------|--------------------------|
| \bar{C} | $\bar{C}\bar{B}\bar{A}=0$ X | $\bar{C}\bar{B}A=1$ X | $\bar{C}BA=3$ X | $\bar{C}B\bar{A}=2$ X |
| C | $C\bar{B}\bar{A}=4$ 1 | $C\bar{B}A=5$ 1 | $CBA=7$ 0 | $CB\bar{A}=6$ 0 |
| | \bar{B} | | B | |

$$K_C = \bar{B}$$



Template For JK Flip-flops (Excitation Table):

For JK Flip-flops (Excitation Table):

| From Q_n | | To Q_{n+1} | J | K | Comment |
|------------|---|--------------|---|---|-----------------|
| 0 | → | 0 | 0 | X | N/C or Reset |
| 0 | → | 1 | 1 | X | Toggle or Set |
| 1 | → | 0 | X | 1 | Toggle or Reset |
| 1 | → | 1 | X | 0 | N/C or Set |

Transition Table

| | Current State | | | | Next State | | | | | | | | |
|----|---------------|-------|-------|-----|------------|-------|-------|-------|-------|-------|-------|-------|-------|
| MT | Q_2 | Q_1 | Q_0 | CLK | Q_2 | Q_1 | Q_0 | J_2 | K_2 | J_1 | K_1 | J_0 | K_0 |
| 0 | 0 | 0 | 0 | ↓ | | | | | | | | | |
| 1 | 0 | 0 | 1 | ↓ | | | | | | | | | |
| 2 | 0 | 1 | 0 | ↓ | | | | | | | | | |
| 3 | 0 | 1 | 1 | ↓ | | | | | | | | | |
| 4 | 1 | 0 | 0 | ↓ | | | | | | | | | |
| 5 | 1 | 0 | 1 | ↓ | | | | | | | | | |
| 6 | 1 | 1 | 0 | ↓ | | | | | | | | | |
| 7 | 1 | 1 | 1 | ↓ | | | | | | | | | |

Karnaugh Map Worksheets (A=Q0, B=Q1, C=Q2)

| | \bar{A} | A | | \bar{A} |
|-----------|---------------------------|---------------------|---------------|---------------------|
| \bar{C} | $\bar{C}\bar{B}\bar{A}=0$ | $\bar{C}\bar{B}A=1$ | $\bar{C}BA=3$ | $\bar{C}B\bar{A}=2$ |
| C | $C\bar{B}\bar{A}=4$ | $C\bar{B}A=5$ | $CBA=7$ | $CB\bar{A}=6$ |
| | \bar{B} | | B | |

| | \bar{A} | A | | \bar{A} |
|-----------|---------------------------|---------------------|---------------|---------------------|
| \bar{C} | $\bar{C}\bar{B}\bar{A}=0$ | $\bar{C}\bar{B}A=1$ | $\bar{C}BA=3$ | $\bar{C}B\bar{A}=2$ |
| C | $C\bar{B}\bar{A}=4$ | $C\bar{B}A=5$ | $CBA=7$ | $CB\bar{A}=6$ |
| | \bar{B} | | B | |

| | \bar{A} | A | | \bar{A} |
|-----------|---------------------------|---------------------|---------------|---------------------|
| \bar{C} | $\bar{C}\bar{B}\bar{A}=0$ | $\bar{C}\bar{B}A=1$ | $\bar{C}BA=3$ | $\bar{C}B\bar{A}=2$ |
| C | $C\bar{B}\bar{A}=4$ | $C\bar{B}A=5$ | $CBA=7$ | $CB\bar{A}=6$ |
| | \bar{B} | | B | |

| | \bar{A} | A | | \bar{A} |
|-----------|---------------------------|---------------------|---------------|---------------------|
| \bar{C} | $\bar{C}\bar{B}\bar{A}=0$ | $\bar{C}\bar{B}A=1$ | $\bar{C}BA=3$ | $\bar{C}B\bar{A}=2$ |
| C | $C\bar{B}\bar{A}=4$ | $C\bar{B}A=5$ | $CBA=7$ | $CB\bar{A}=6$ |
| | \bar{B} | | B | |

| | \bar{A} | A | | \bar{A} |
|-----------|---------------------------|---------------------|---------------|---------------------|
| \bar{C} | $\bar{C}\bar{B}\bar{A}=0$ | $\bar{C}\bar{B}A=1$ | $\bar{C}BA=3$ | $\bar{C}B\bar{A}=2$ |
| C | $C\bar{B}\bar{A}=4$ | $C\bar{B}A=5$ | $CBA=7$ | $CB\bar{A}=6$ |
| | \bar{B} | | B | |

| | \bar{A} | A | | \bar{A} |
|-----------|---------------------------|---------------------|---------------|---------------------|
| \bar{C} | $\bar{C}\bar{B}\bar{A}=0$ | $\bar{C}\bar{B}A=1$ | $\bar{C}BA=3$ | $\bar{C}B\bar{A}=2$ |
| C | $C\bar{B}\bar{A}=4$ | $C\bar{B}A=5$ | $CBA=7$ | $CB\bar{A}=6$ |
| | \bar{B} | | B | |