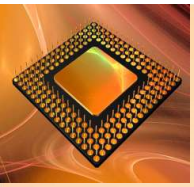
Modern Digital System Design

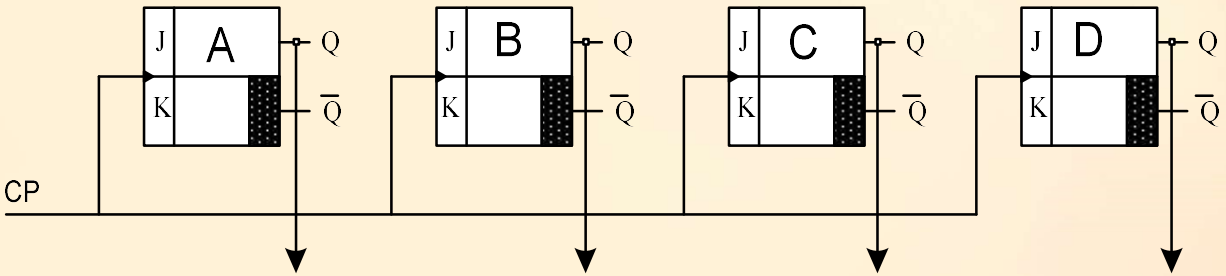
ECE 2372 / Fall 2018 / Lecture 12

Texas Tech University
Dr. Tooraj Nikoubin

Counters



BCD Counter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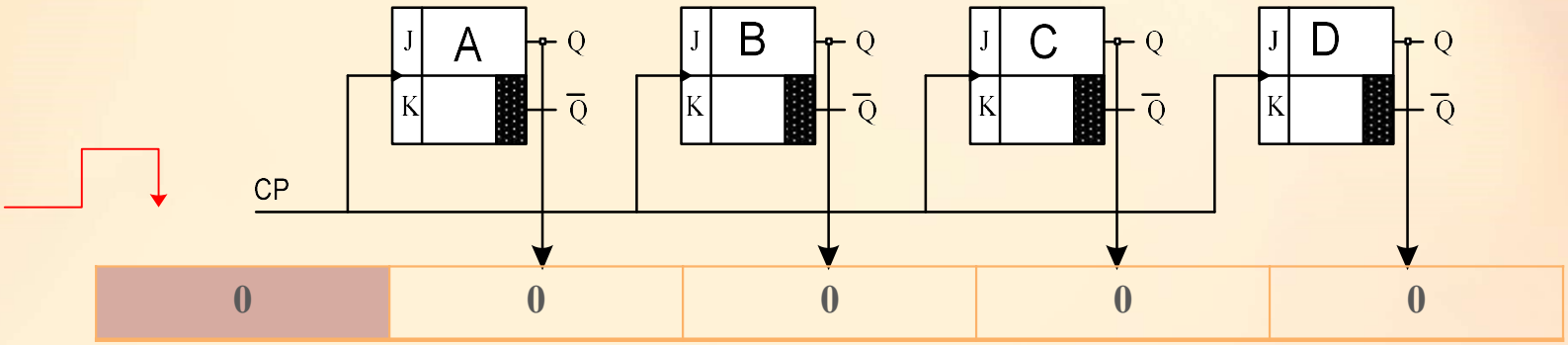
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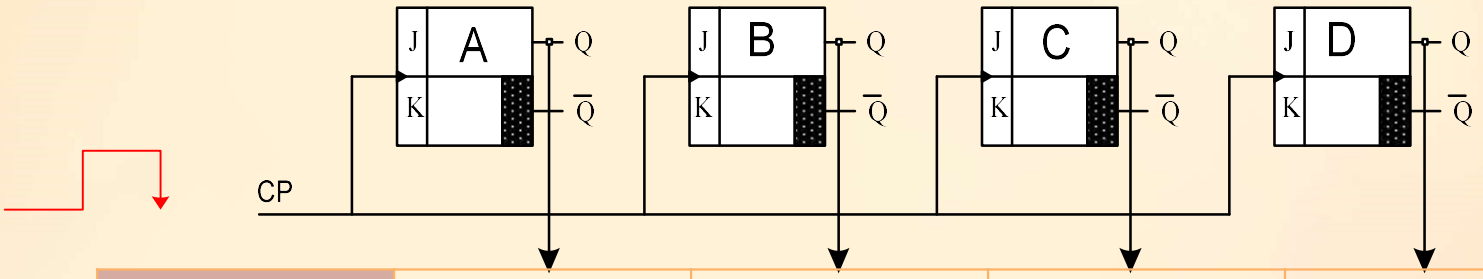

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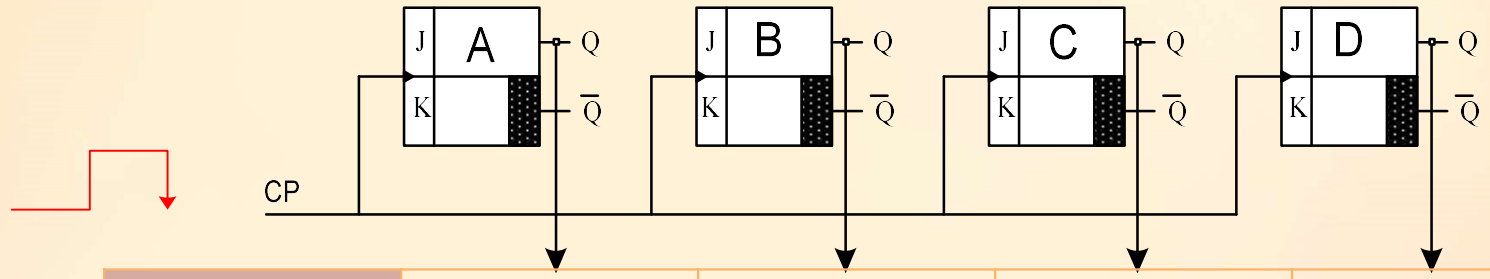

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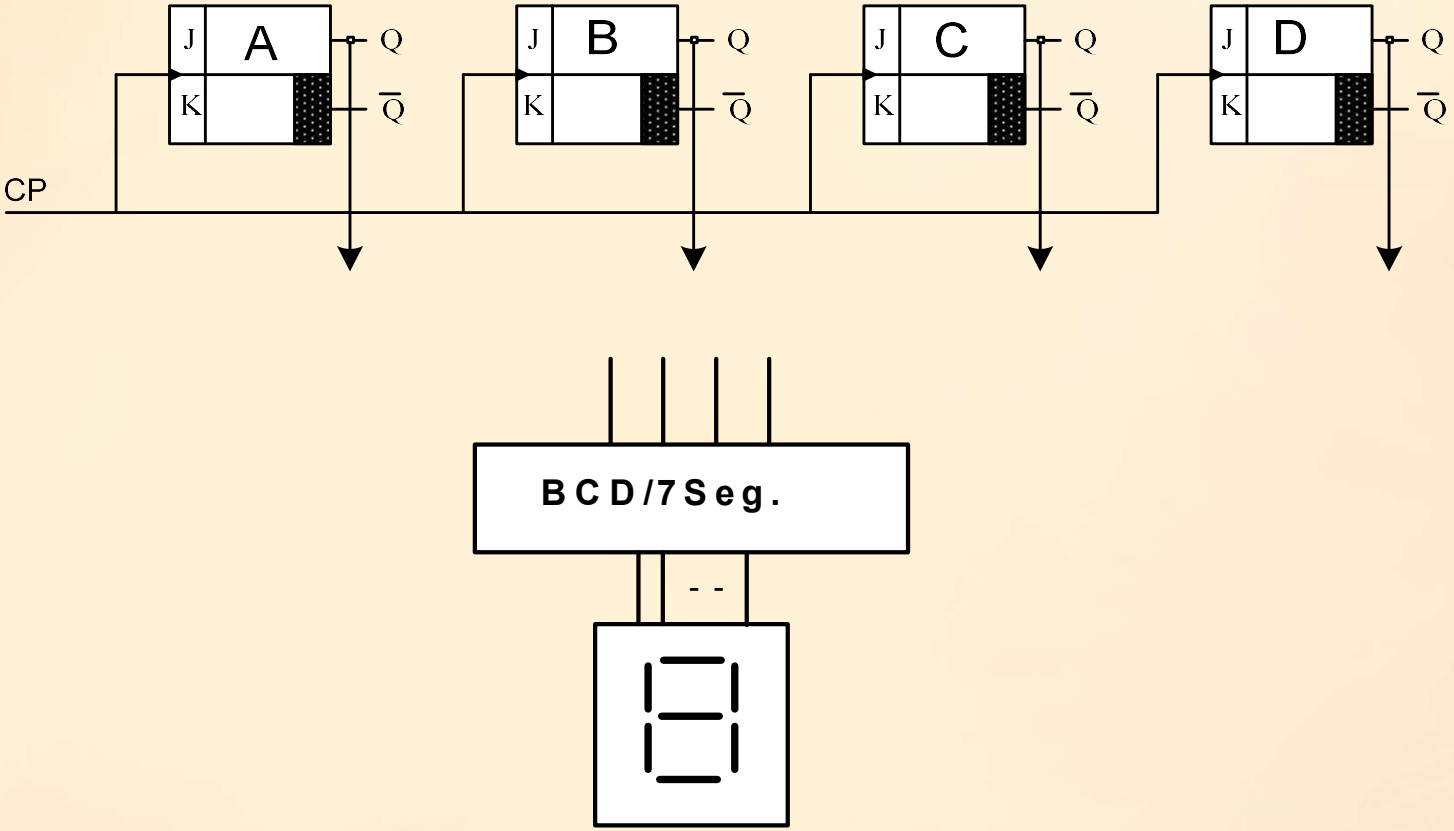
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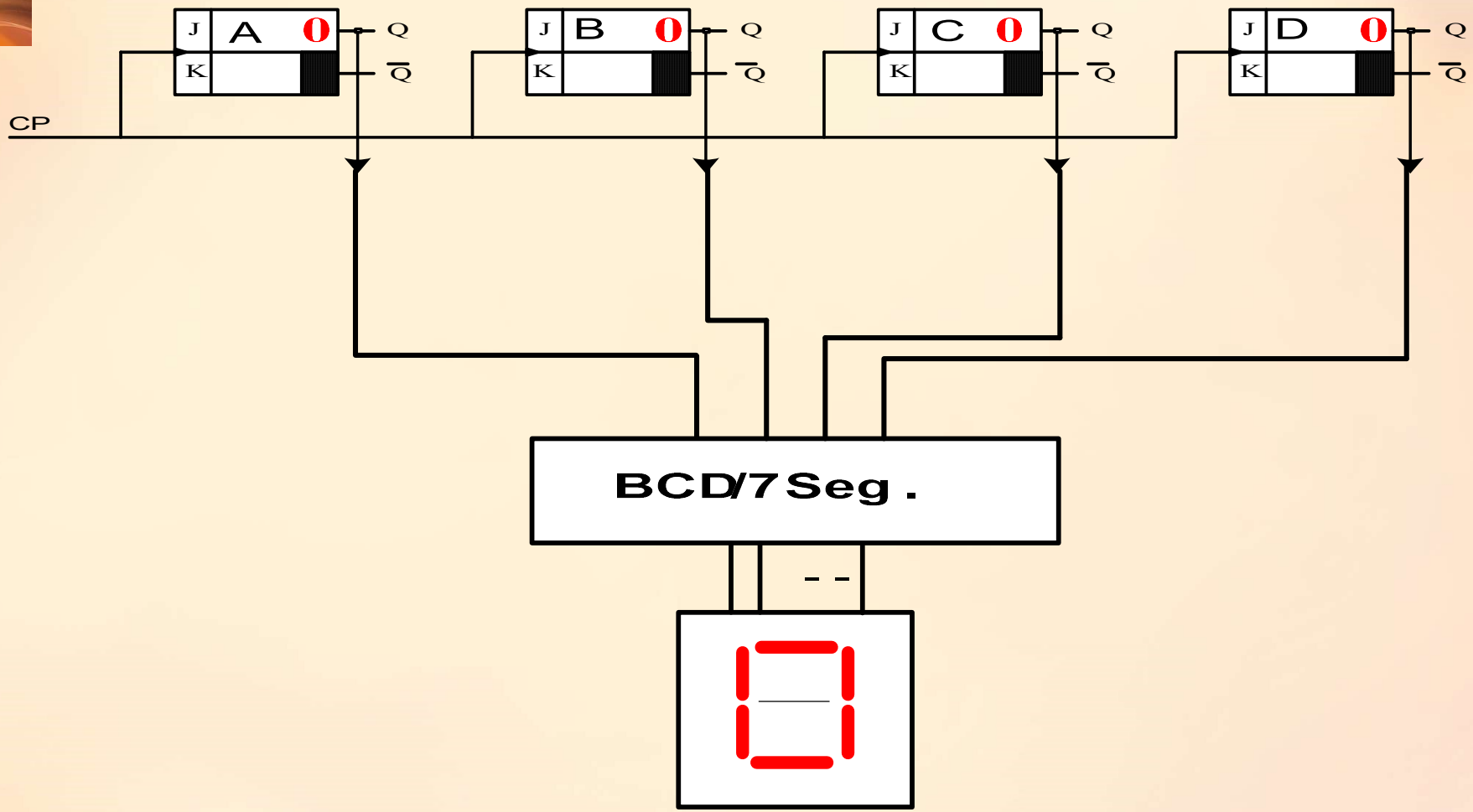
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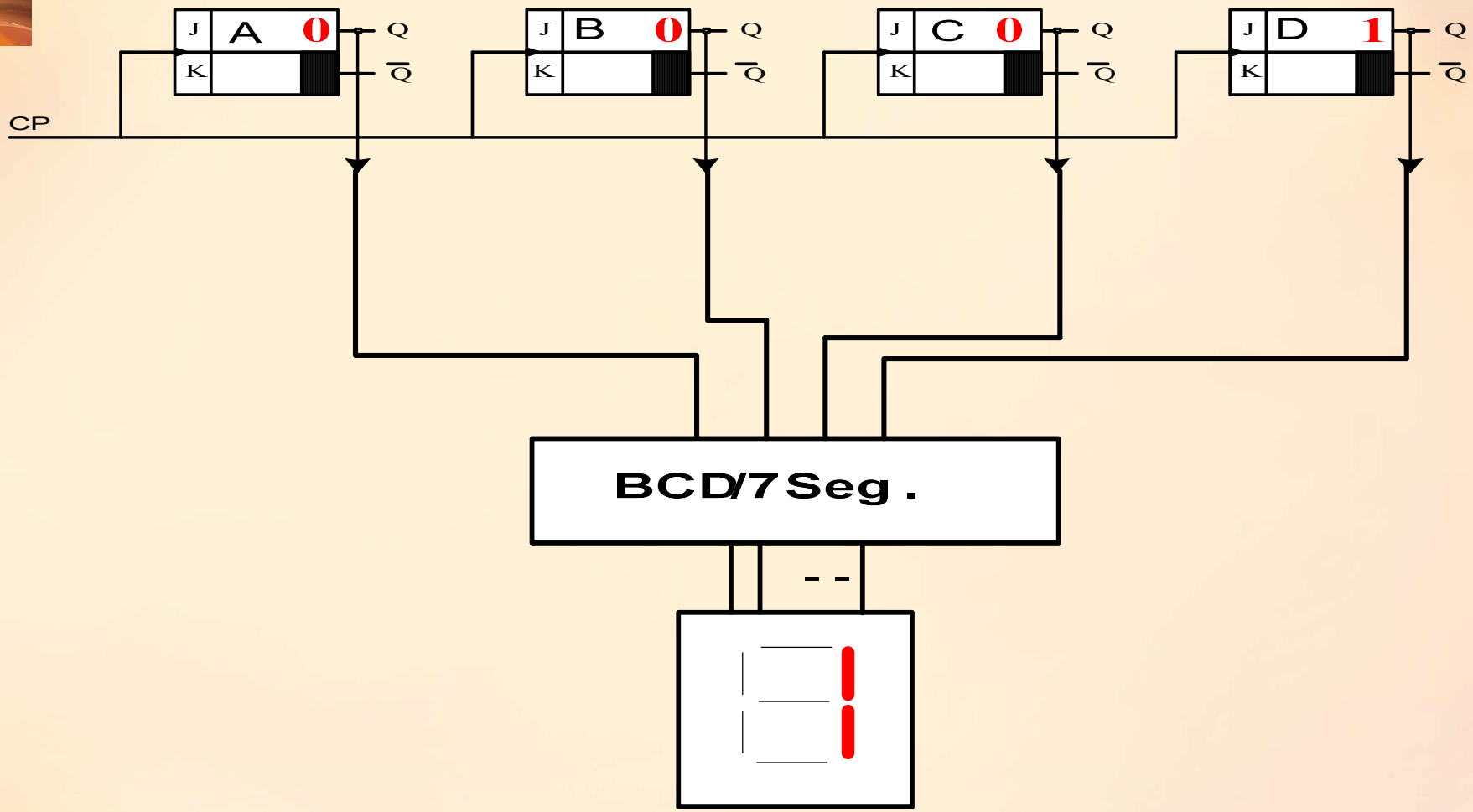
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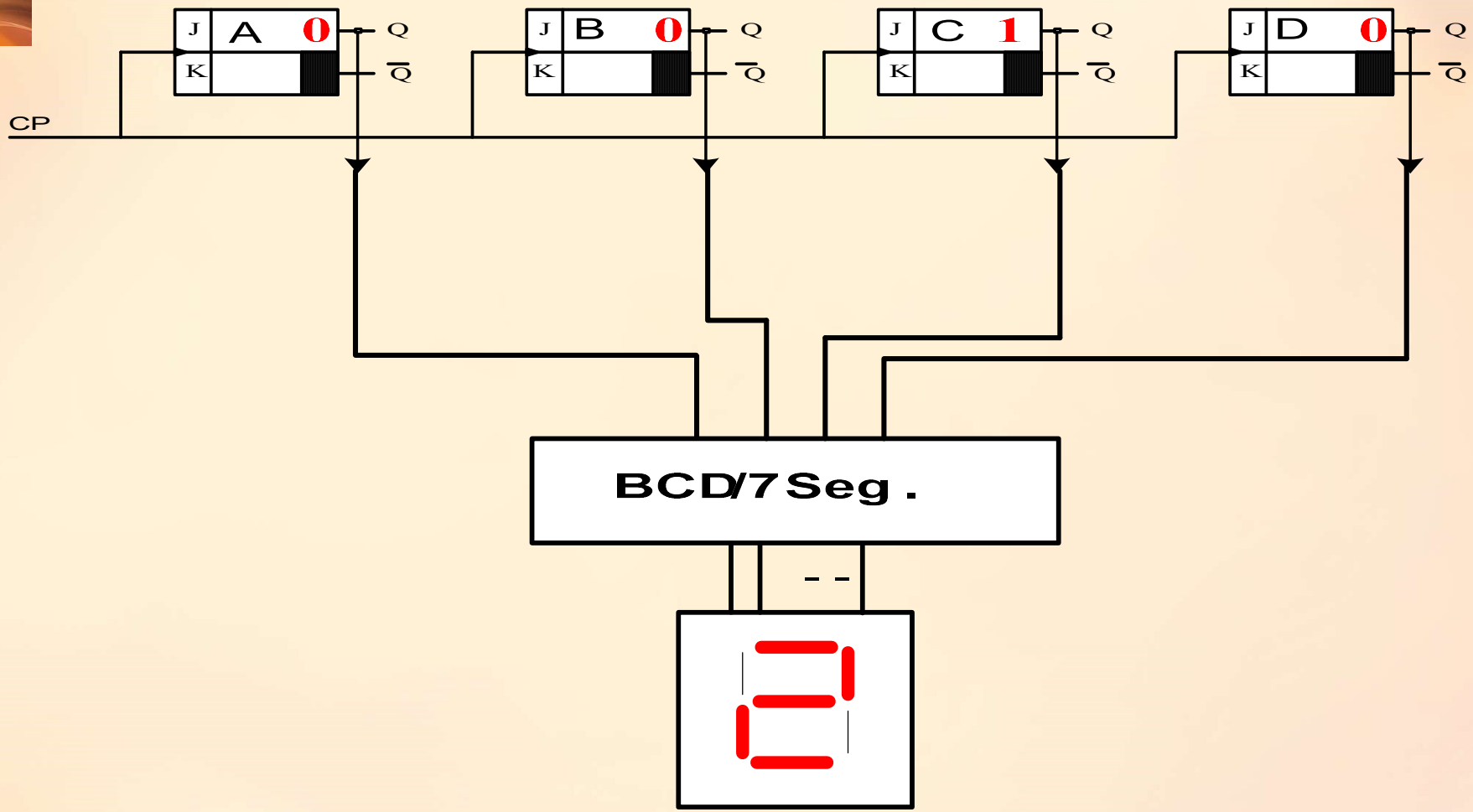
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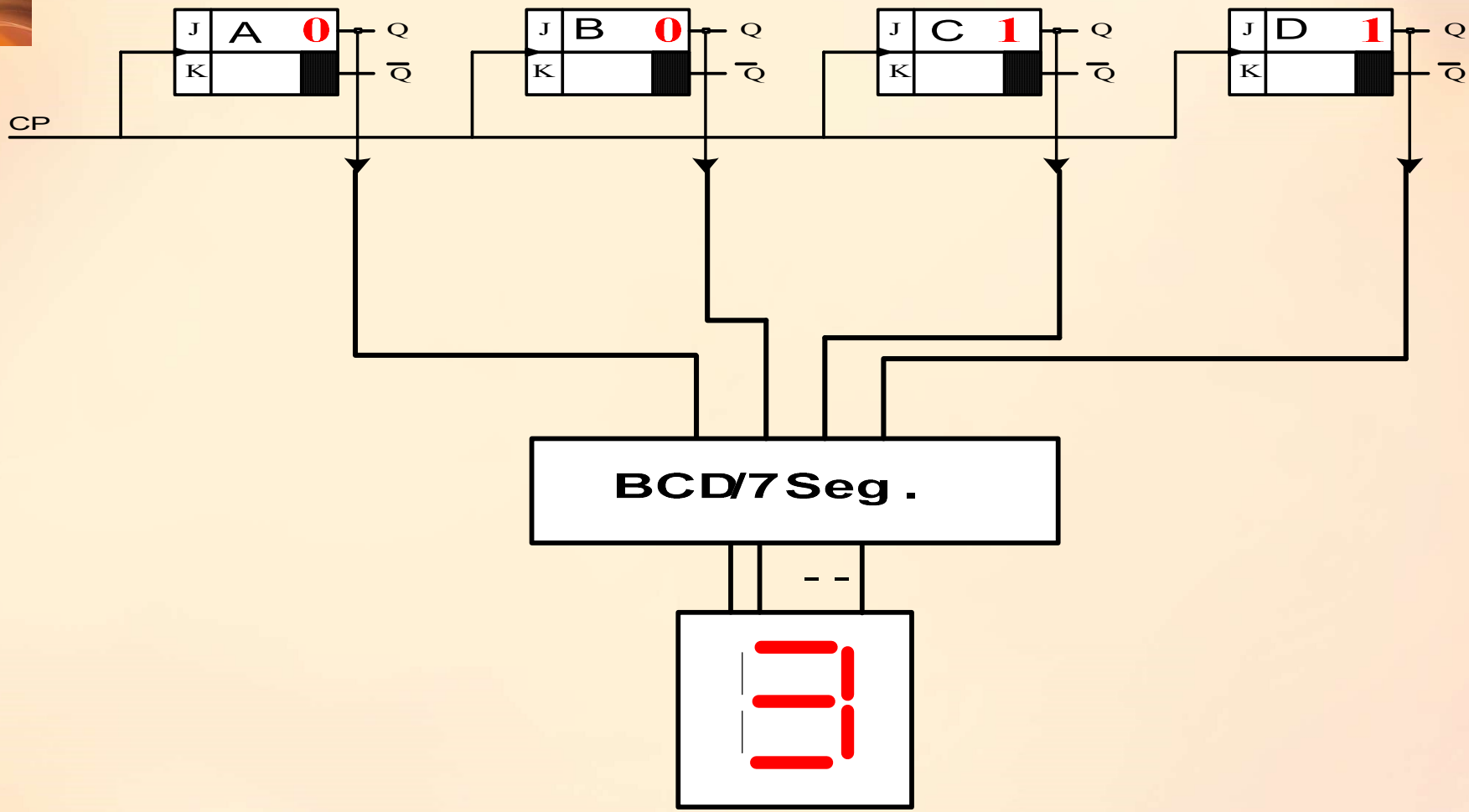
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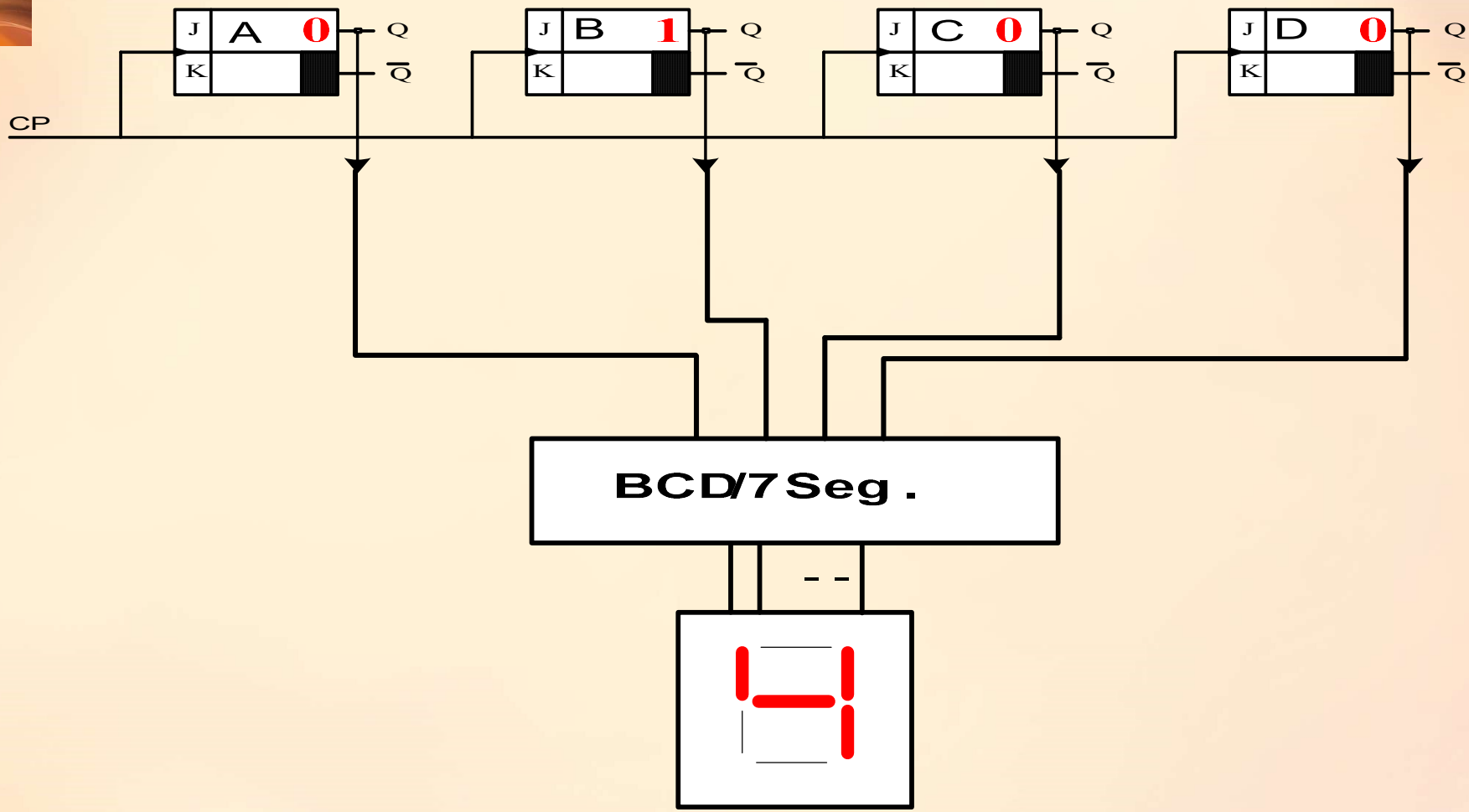
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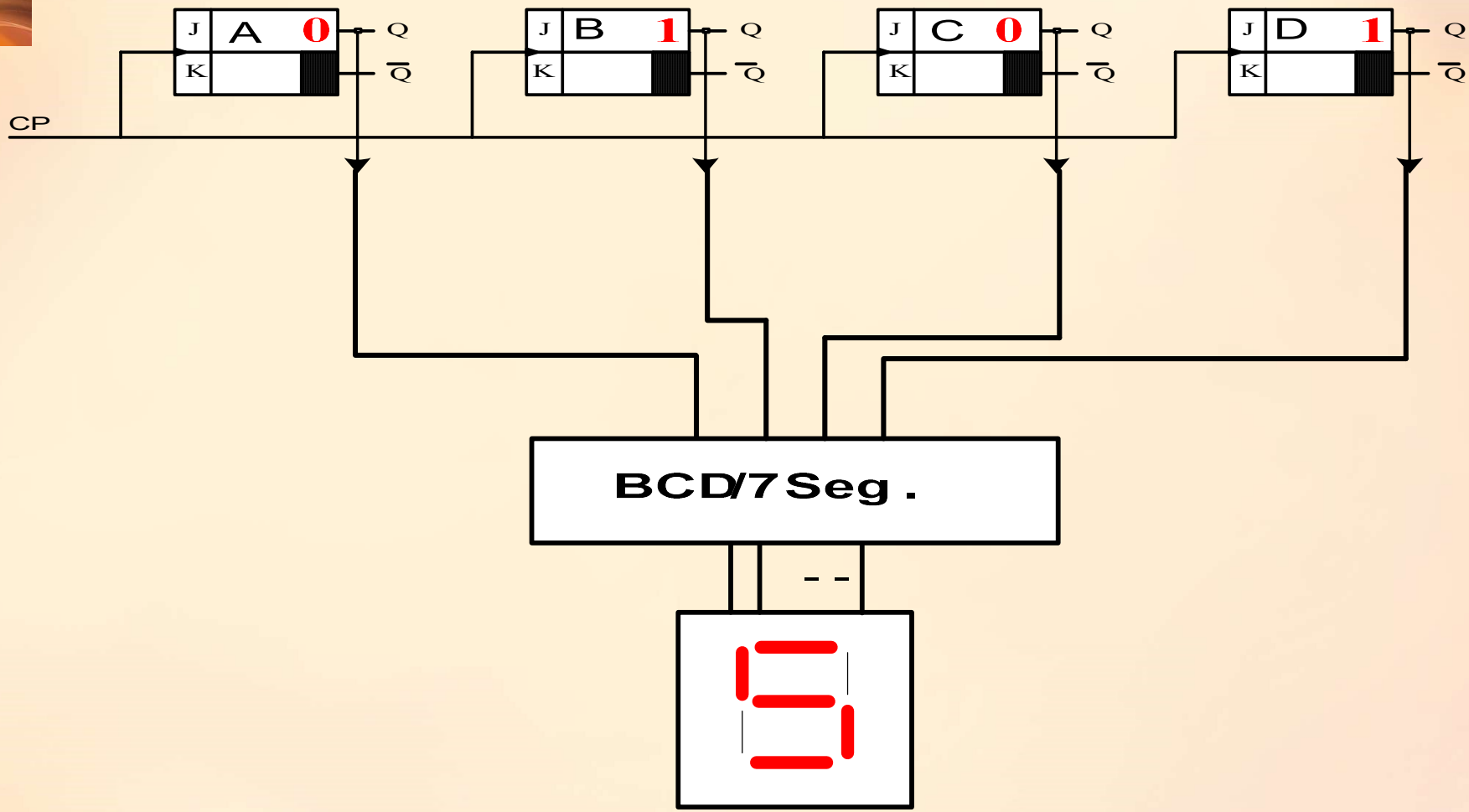
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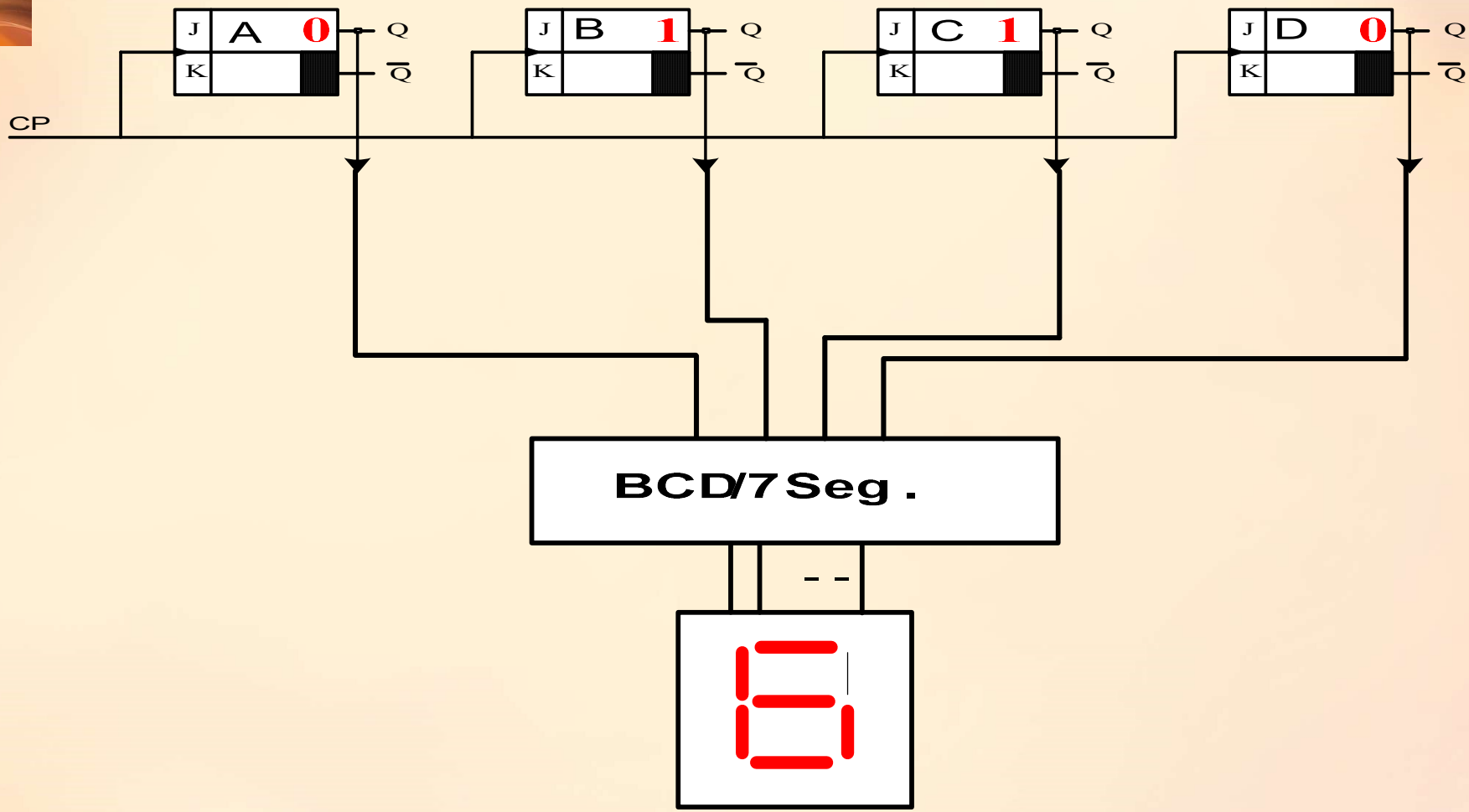
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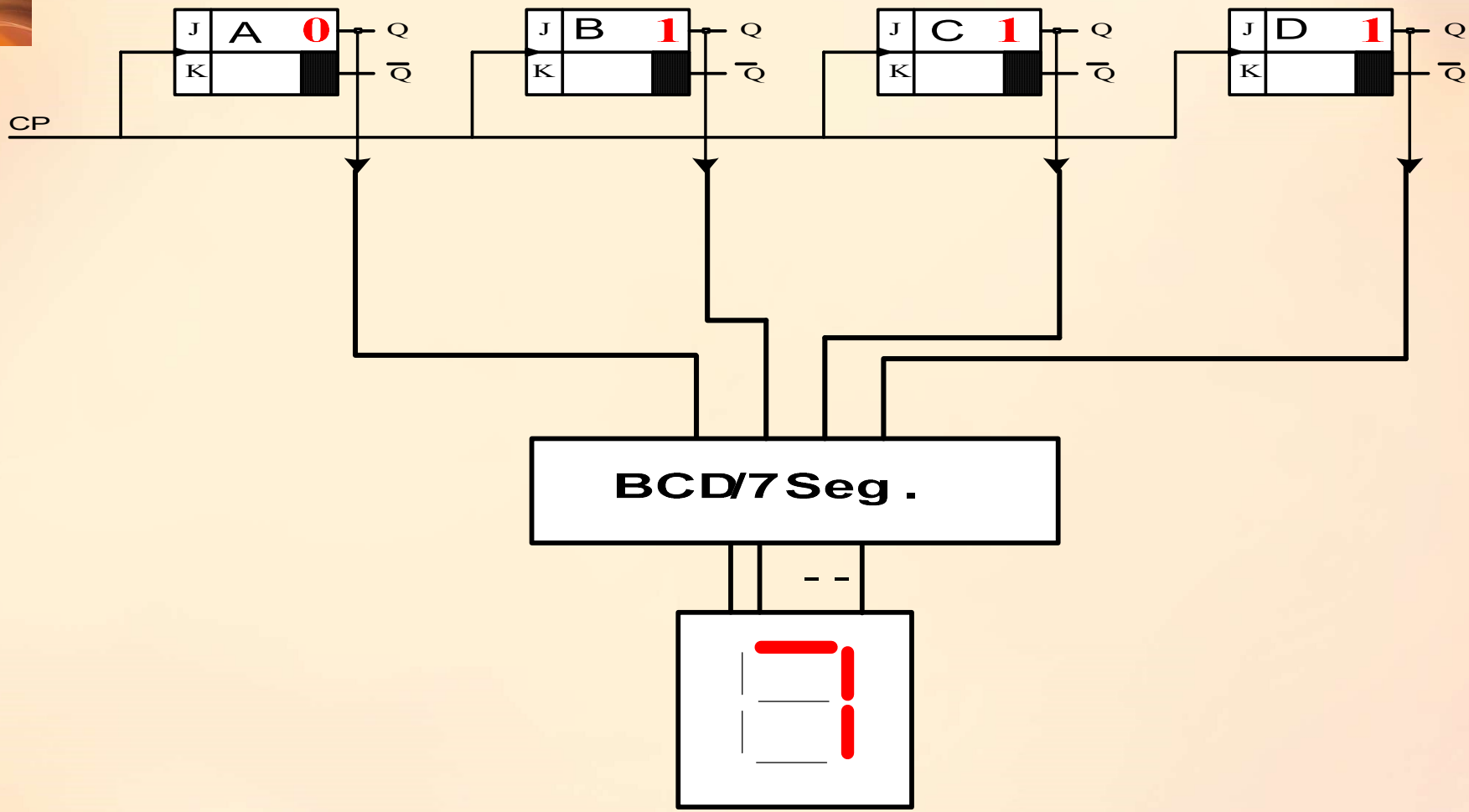
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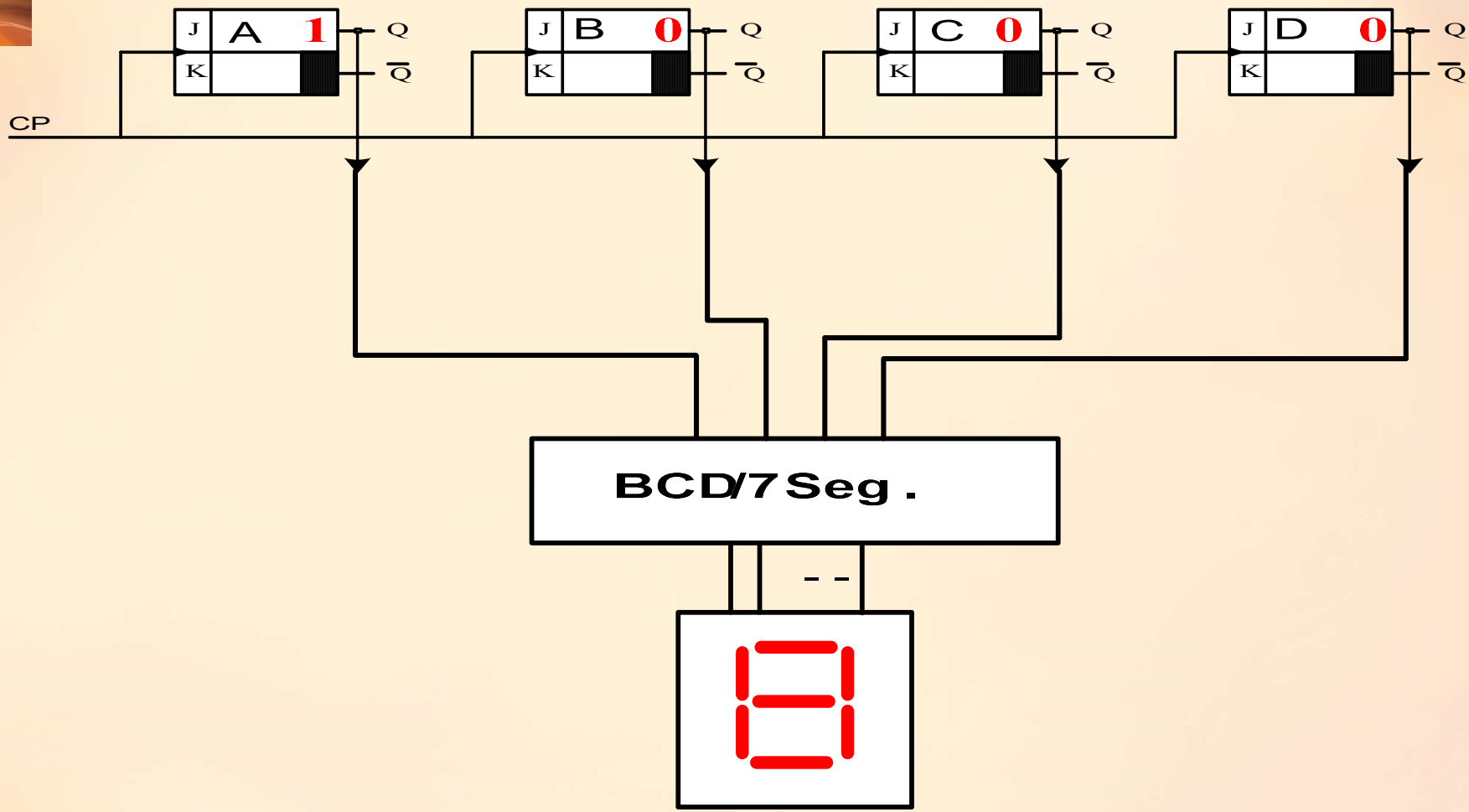
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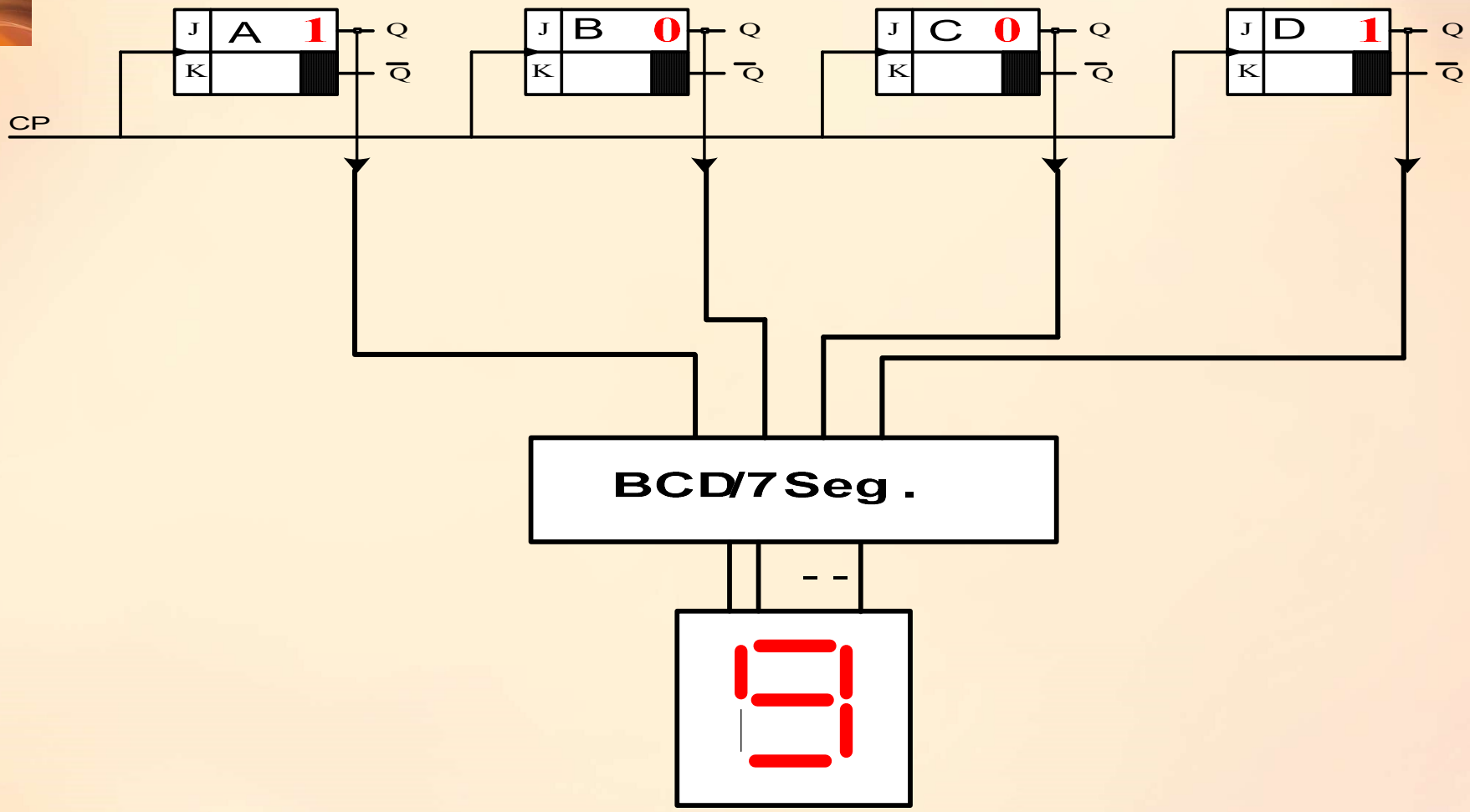
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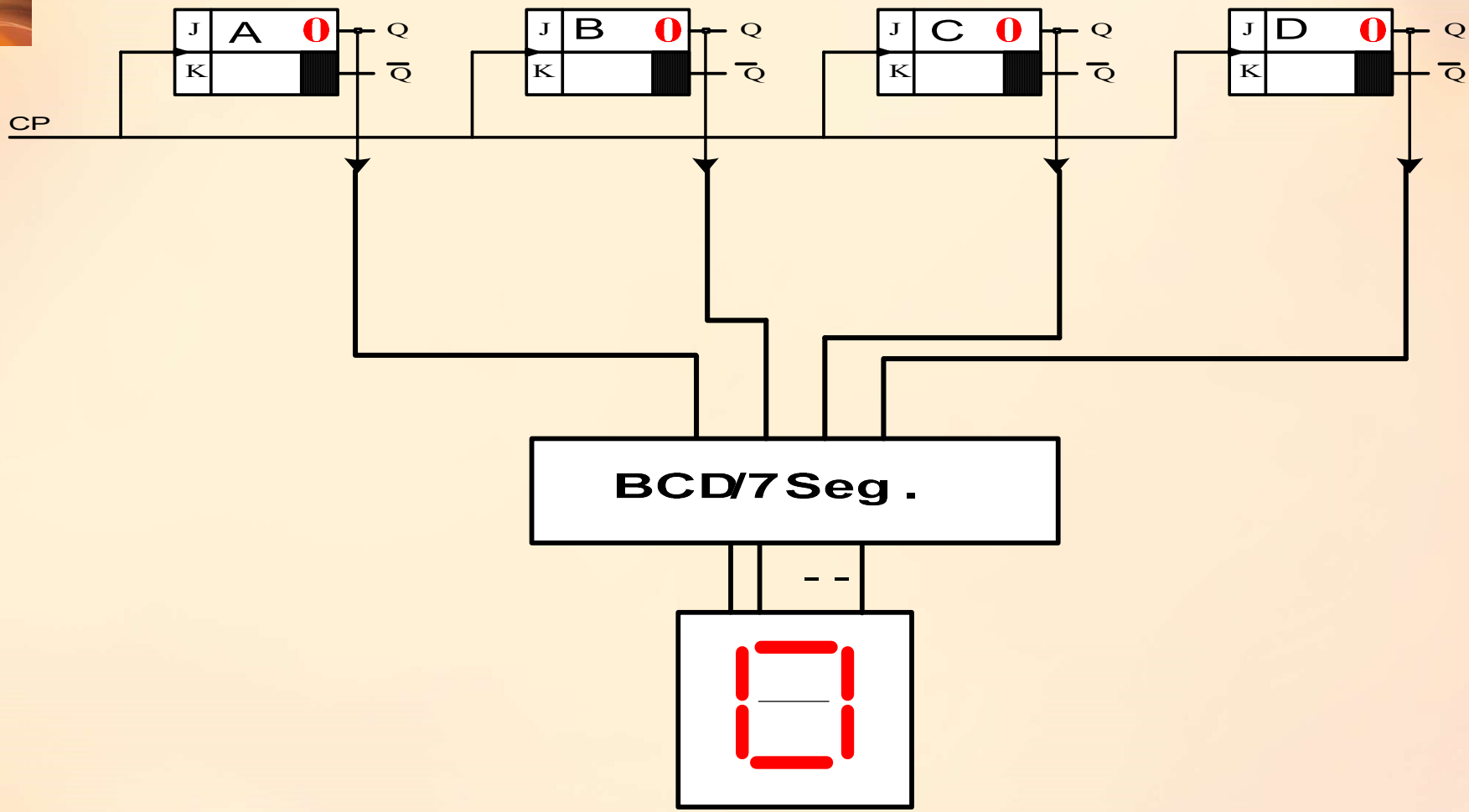
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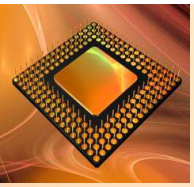


DESIGN OF COUNT UP BCD COUNTER

DESIGN OF COUNT UP BCD COUNTER

With

1- JK-MS-FF

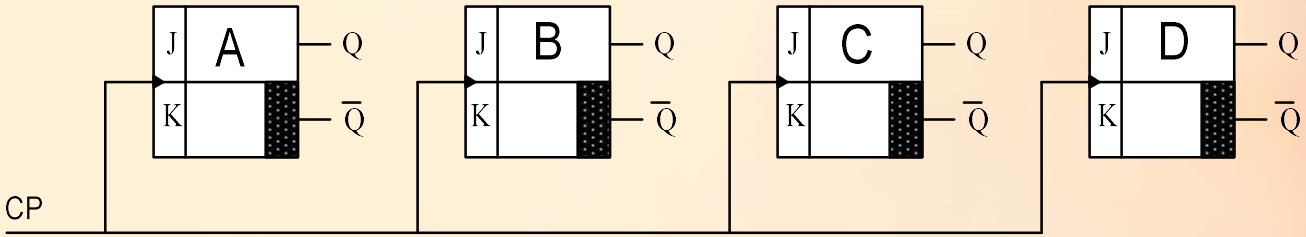
2- RS-FF

3- D-FF

4- T-FF

DESIGN OF COUNT UP BCD COUNTER WITH JK-MS-FF

BCD				
	A	B	C	D
0	0	0	0	0
1	0	0	0	1
2	0	0	1	0
3	0	0	1	1
4	0	1	0	0
5	0	1	0	1
6	0	1	1	0
7	0	1	1	1
8	1	0	0	0
9	1	0	0	1
0	0	0	0	0



$Ji=\sum m(\ 0 \Rightarrow 1)$

$Ki=\sum m(\ 1 \Rightarrow 0)$

DESIGN OF COUNT UP BCD COUNTER WITH JK-MS-FF

BCD				
	A	B	C	D
0	0	0	0	0
1	0	0	0	1
2	0	0	1	0
3	0	0	1	1
4	0	1	0	0
5	0	1	0	1
6	0	1	1	0
7	0	1	1	1
8	1	0	0	0
9	1	0	0	1
0	0	0	0	0

$JD=\sum m(0,2,4,6,8)$

DESIGN OF COUNT UP BCD COUNTER WITH JK-MS-FF

BCD				
	A	B	C	D
0	0	0	0	0
1	0	0	0	1
2	0	0	1	0
3	0	0	1	1
4	0	1	0	0
5	0	1	0	1
6	0	1	1	0
7	0	1	1	1
8	1	0	0	0
9	1	0	0	1
0	0	0	0	0

$JD=\sum m(0,2,4,6,8)$

$KD=\sum m(1,3,5,7,9)$

DESIGN OF COUNT UP BCD COUNTER WITH JK-MS-FF

BCD				
	A	B	C	D
0	0	0	0	0
1	0	0	0	1
2	0	0	1	0
3	0	0	1	1
4	0	1	0	0
5	0	1	0	1
6	0	1	1	0
7	0	1	1	1
8	1	0	0	0
9	1	0	0	1
0	0	0	0	0

$JD=\sum m(0,2,4,6,8)$

$KD=\sum m(1,3,5,7,9)$

$JC=\sum m(1,5)$

DESIGN OF COUNT UP BCD COUNTER WITH JK-MS-FF

BCD				
	A	B	C	D
0	0	0	0	0
1	0	0	0	1
2	0	0	1	0
3	0	0	1	1
4	0	1	0	0
5	0	1	0	1
6	0	1	1	0
7	0	1	1	1
8	1	0	0	0
9	1	0	0	1
0	0	0	0	0

$JD=\sum m(0,2,4,6,8)$

$KD=\sum m(1,3,5,7,9)$

$JC=\sum m(1,5)$

$KC=\sum m(3,7)$

DESIGN OF COUNT UP BCD COUNTER WITH JK-MS-FF

BCD				
	A	B	C	D
0	0	0	0	0
1	0	0	0	1
2	0	0	1	0
3	0	0	1	1
4	0	1	0	0
5	0	1	0	1
6	0	1	1	0
7	0	1	1	1
8	1	0	0	0
9	1	0	0	1
0	0	0	0	0

$JD=\sum m(0,2,4,6,8)$

$KD=\sum m(1,3,5,7,9)$

$JC=\sum m(1,5)$

$KC=\sum m(3,7)$

$JB=\sum m(3)$

DESIGN OF COUNT UP BCD COUNTER WITH JK-MS-FF

BCD				
	A	B	C	D
0	0	0	0	0
1	0	0	0	1
2	0	0	1	0
3	0	0	1	1
4	0	1	0	0
5	0	1	0	1
6	0	1	1	0
7	0	1	1	1
8	1	0	0	0
9	1	0	0	1
0	0	0	0	0

$JD=\sum m(0,2,4,6,8)$

$KD=\sum m(1,3,5,7,9)$

$JC=\sum m(1,5)$

$KC=\sum m(3,7)$

$JB=\sum m(3)$

$KB=\sum m(7)$

DESIGN OF COUNT UP BCD COUNTER WITH JK-MS-FF

BCD				
	A	B	C	D
0	0	0	0	0
1	0	0	0	1
2	0	0	1	0
3	0	0	1	1
4	0	1	0	0
5	0	1	0	1
6	0	1	1	0
7	0	1	1	1
8	1	0	0	0
9	1	0	0	1
0	0	0	0	0

$JD=\sum m(0,2,4,6,8)$

$KD=\sum m(1,3,5,7,9)$

$JC=\sum m(1,5)$

$KC=\sum m(3,7)$

$JB=\sum m(3)$

$KB=\sum m(7)$

$JA=\sum m(7)$

DESIGN OF COUNT UP BCD COUNTER WITH JK-MS-FF

BCD				
	A	B	C	D
0	0	0	0	0
1	0	0	0	1
2	0	0	1	0
3	0	0	1	1
4	0	1	0	0
5	0	1	0	1
6	0	1	1	0
7	0	1	1	1
8	1	0	0	0
9	1	0	0	1
0	0	0	0	0

$JD=\sum m(0,2,4,6,8)$

$KD=\sum m(1,3,5,7,9)$

$JC=\sum m(1,5)$

$KC=\sum m(3,7)$

$JB=\sum m(3)$

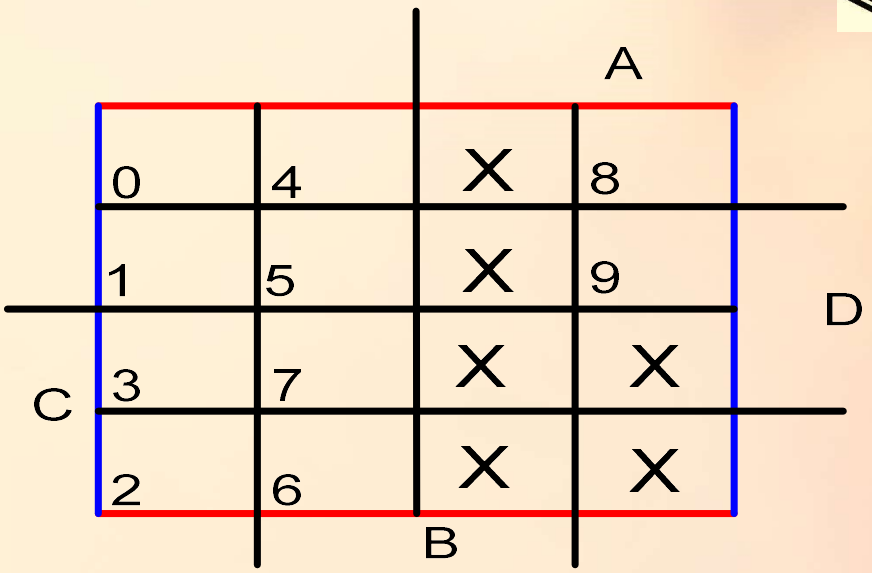
$KB=\sum m(7)$

$JA=\sum m(7)$

$KA=\sum m(9)$

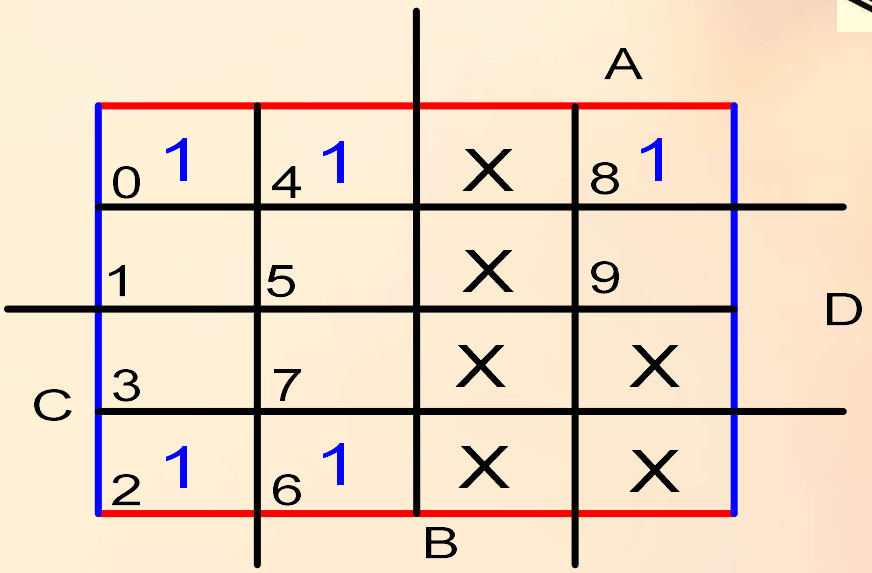
DESIGN OF COUNT UP BCD COUNTER WITH JK-MS-FF

$JD=\sum m(0,2,4,6,8)=$



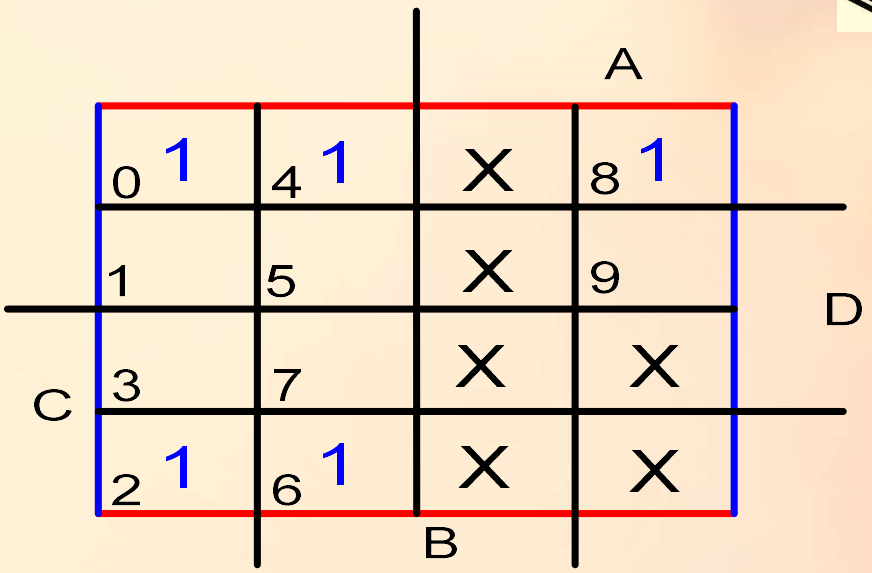
DESIGN OF COUNT UP BCD COUNTER WITH JK-MS-FF

$JD=\sum m(0,2,4,6,8)=$



DESIGN OF COUNT UP BCD COUNTER WITH JK-MS-FF

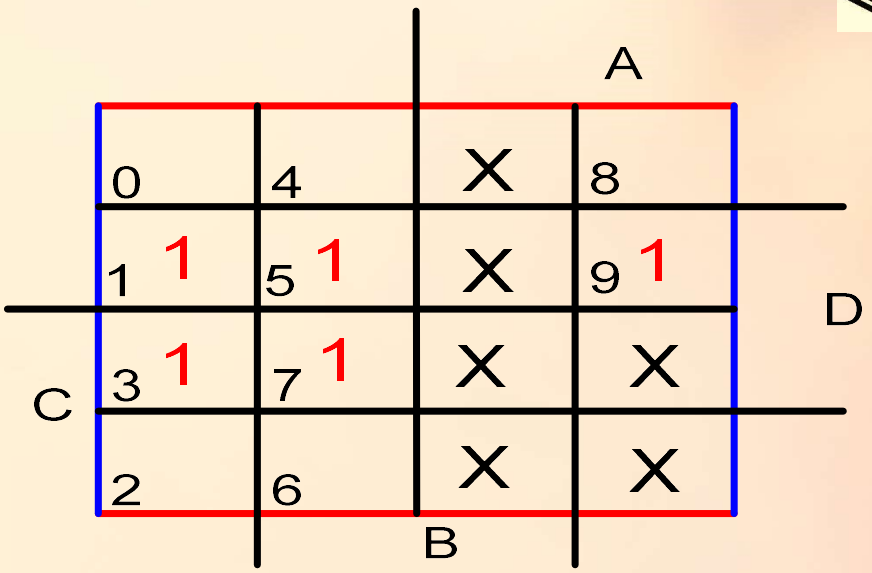
$JD=\sum m(0,2,4,6,8)=D'$



DESIGN OF COUNT UP BCD COUNTER WITH JK-MS-FF

JD=∑m(0,2,4,6,8)=D’

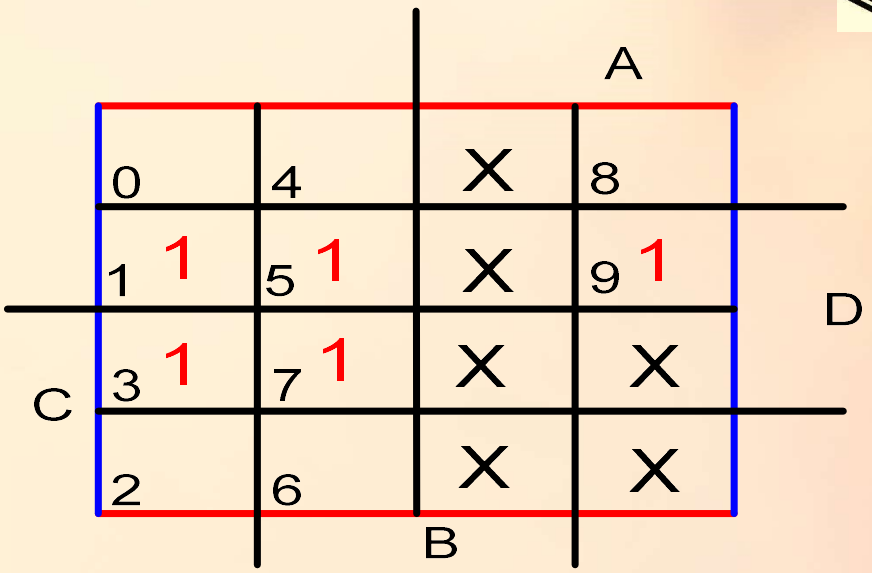
KD=∑m(1,3,5,7,9)=



DESIGN OF COUNT UP BCD COUNTER WITH JK-MS-FF

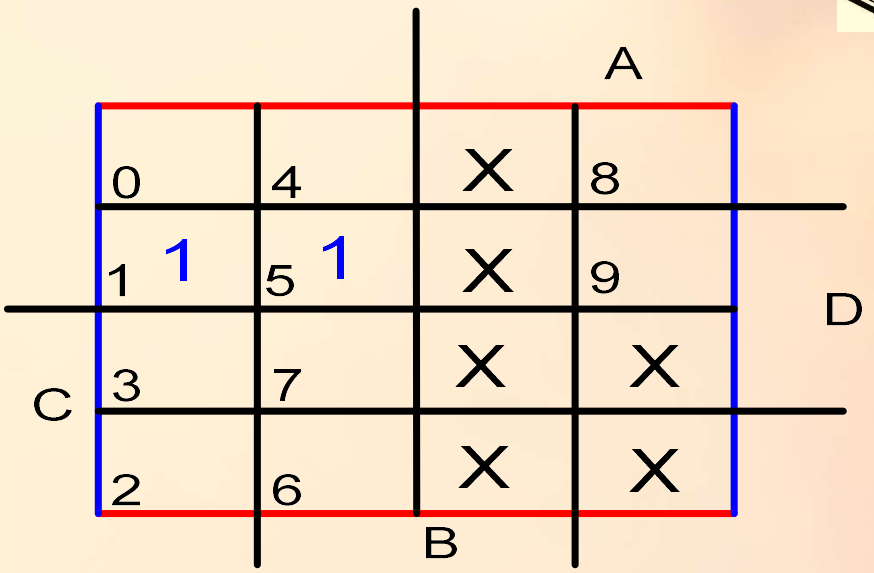
$JD=\sum m(0,2,4,6,8)=D'$

$KD=\sum m(1,3,5,7,9)=D$



DESIGN OF COUNT UP BCD COUNTER WITH JK-MS-FF

JD=∑m(0,2,4,6,8)=D’
KD=∑m(1,3,5,7,9)=D
JC=∑m(1,5)=

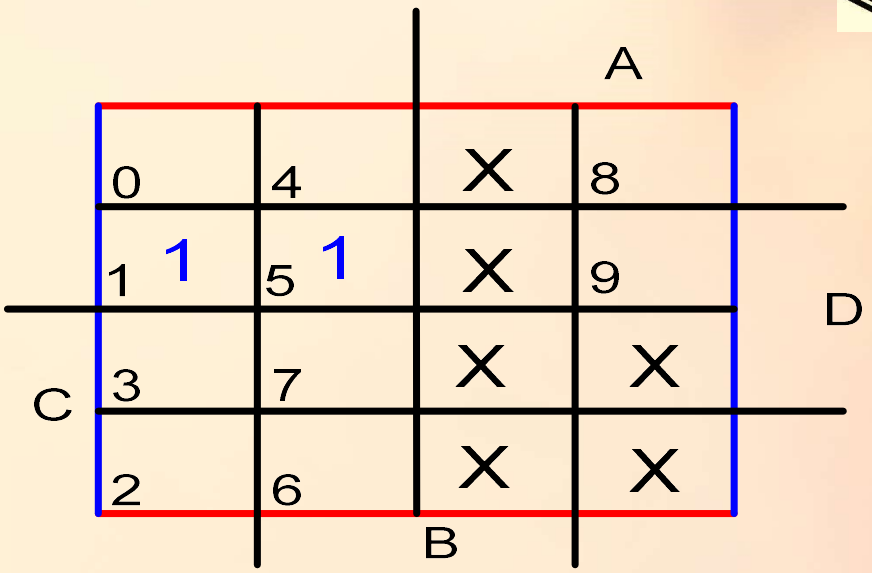


DESIGN OF COUNT UP BCD COUNTER WITH JK-MS-FF

$JD=\sum m(0,2,4,6,8)=D'$

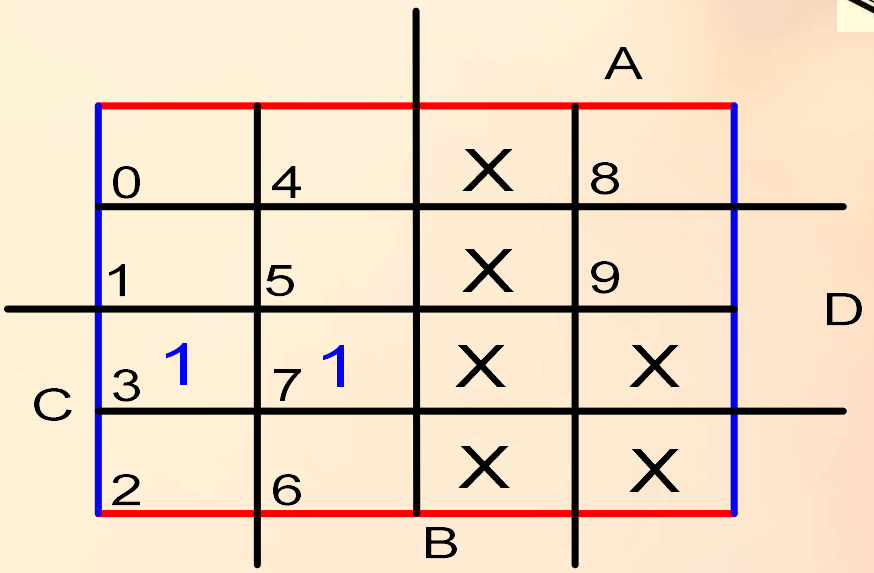
$KD=\sum m(1,3,5,7,9)=D$

$JC=\sum m(1,5)=A'C'D$



DESIGN OF COUNT UP BCD COUNTER WITH JK-MS-FF

JD=∑m(0,2,4,6,8)=D’
KD=∑m(1,3,5,7,9)=D
JC=∑m(1,5)=A’C’D
KC=∑m(3,7)=



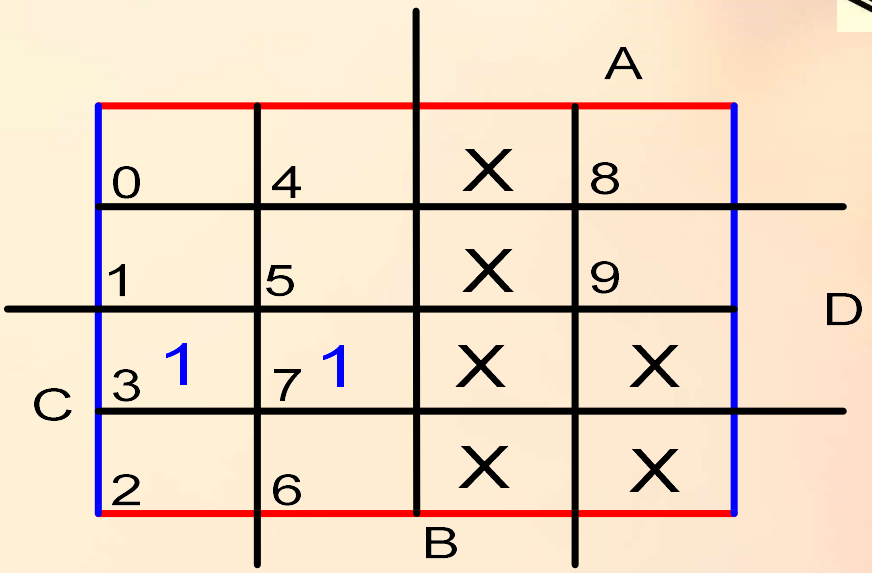
DESIGN OF COUNT UP BCD COUNTER WITH JK-MS-FF

$JD=\sum m(0,2,4,6,8)=D'$

$KD=\sum m(1,3,5,7,9)=D$

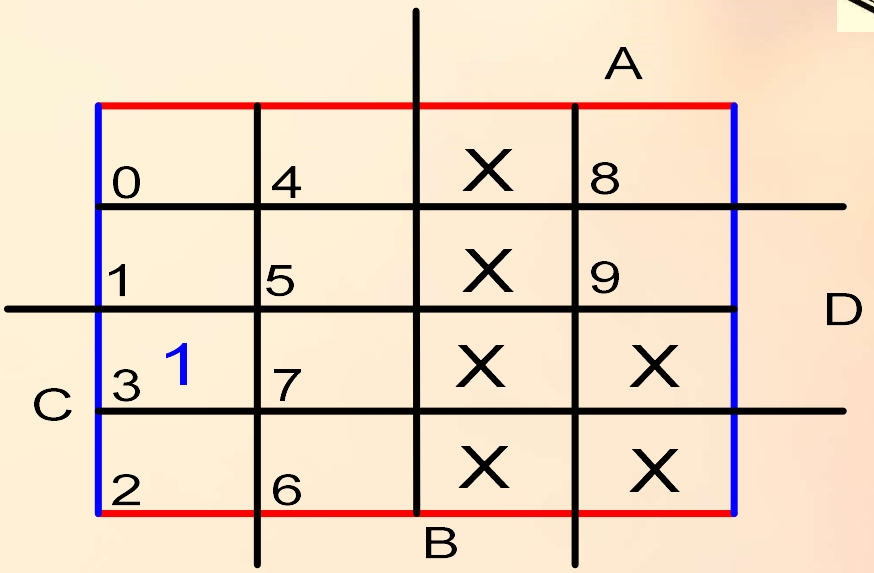
$JC=\sum m(1,5)=A'C'D$

$KC=\sum m(3,7)=CD$



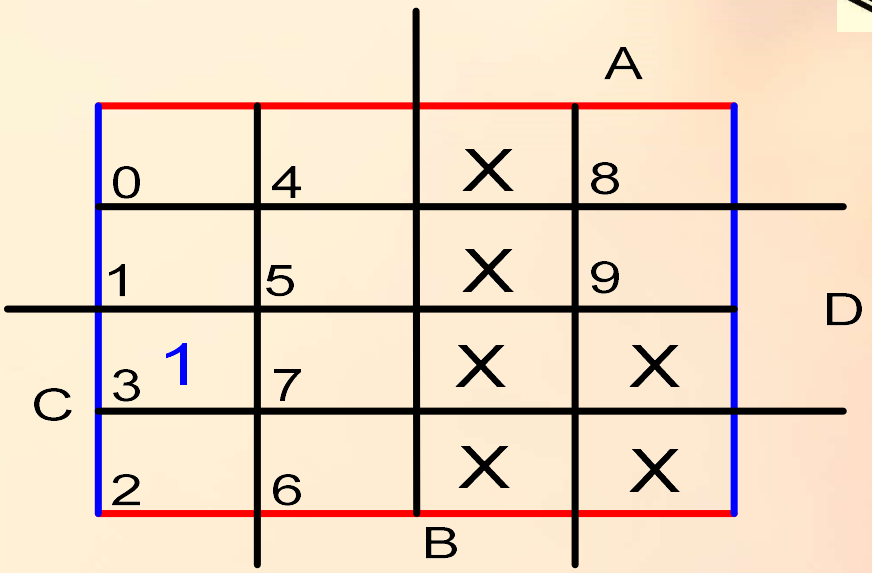
DESIGN OF COUNT UP BCD COUNTER WITH JK-MS-FF

JD=∑m(0,2,4,6,8)=D’
KD=∑m(1,3,5,7,9)=D
JC=∑m(1,5)=A’C’D
KC=∑m(3,7)=CD
JB=∑m(3)=



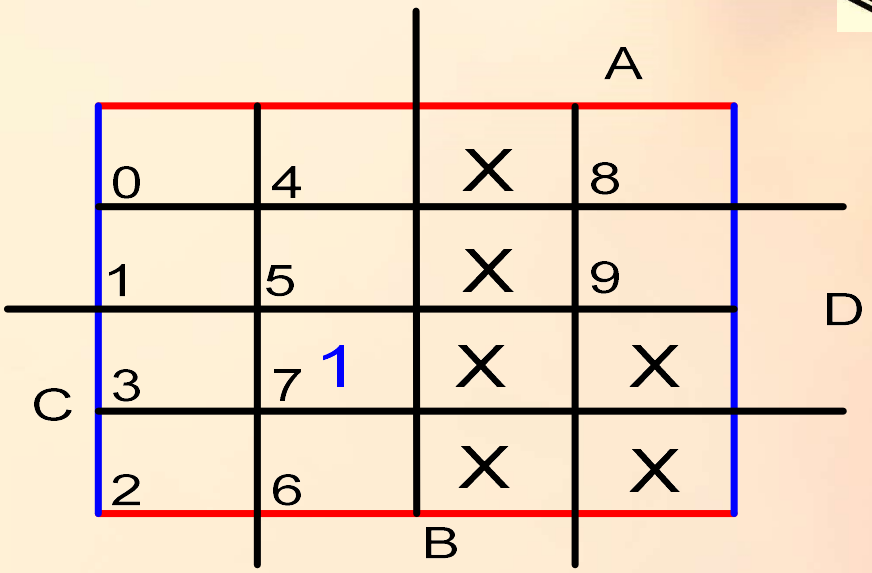
DESIGN OF COUNT UP BCD COUNTER WITH JK-MS-FF

JD=∑m(0,2,4,6,8)=D’
KD=∑m(1,3,5,7,9)=D
JC=∑m(1,5)=A’C’D
KC=∑m(3,7)=CD
JB=∑m(3)=B’CD



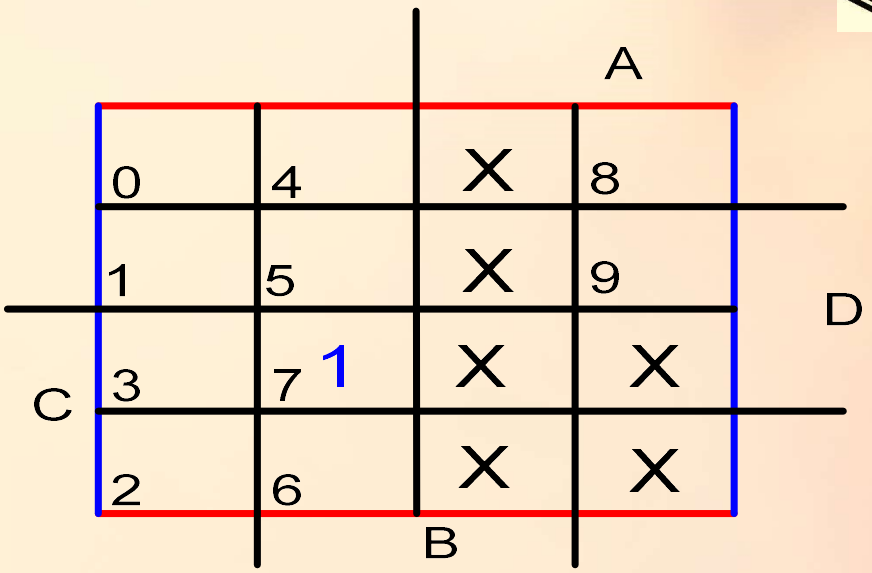
DESIGN OF COUNT UP BCD COUNTER WITH JK-MS-FF

JD=∑m(0,2,4,6,8)=D’
KD=∑m(1,3,5,7,9)=D
JC=∑m(1,5)=A’C’D
KC=∑m(3,7)=CD
JB=∑m(3)=B’CD
KB=∑m(7)=



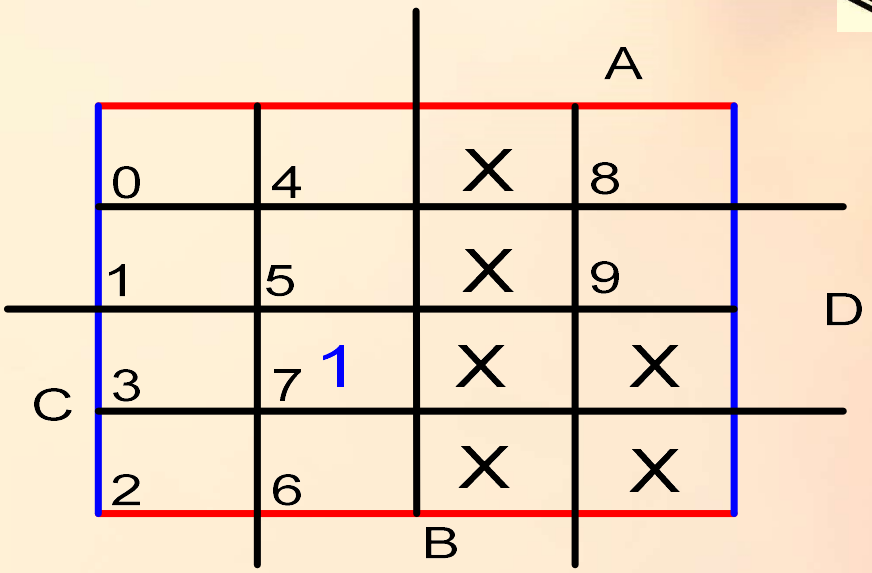
DESIGN OF COUNT UP BCD COUNTER WITH JK-MS-FF

JD=∑m(0,2,4,6,8)=D’
KD=∑m(1,3,5,7,9)=D
JC=∑m(1,5)=A’C’D
KC=∑m(3,7)=CD
JB=∑m(3)=B’CD
KB=∑m(7)=BCD



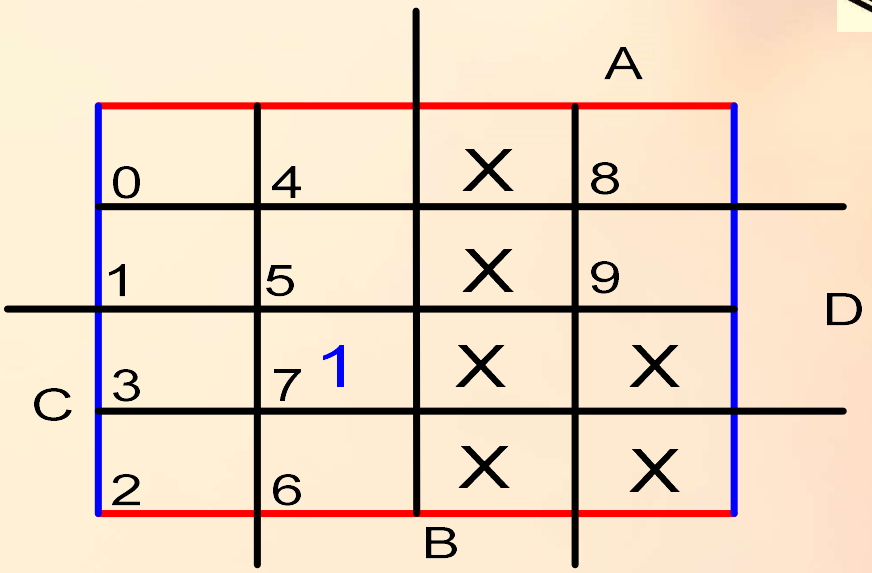
DESIGN OF COUNT UP BCD COUNTER WITH JK-MS-FF

JD=∑m(0,2,4,6,8)=D’
KD=∑m(1,3,5,7,9)=D
JC=∑m(1,5)=A’C’D
KC=∑m(3,7)=CD
JB=∑m(3)=B’CD
KB=∑m(7)=BCD
JA=∑m(7)=



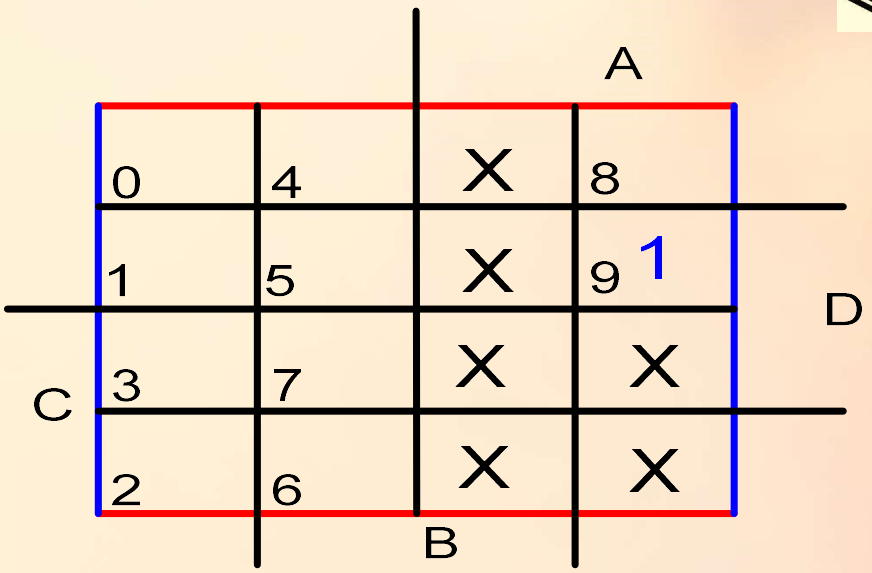
DESIGN OF COUNT UP BCD COUNTER WITH JK-MS-FF

JD=∑m(0,2,4,6,8)=D’
KD=∑m(1,3,5,7,9)=D
JC=∑m(1,5)=A’C’D
KC=∑m(3,7)=CD
JB=∑m(3)=B’CD
KB=∑m(7)=BCD
JA=∑m(7)=BCD



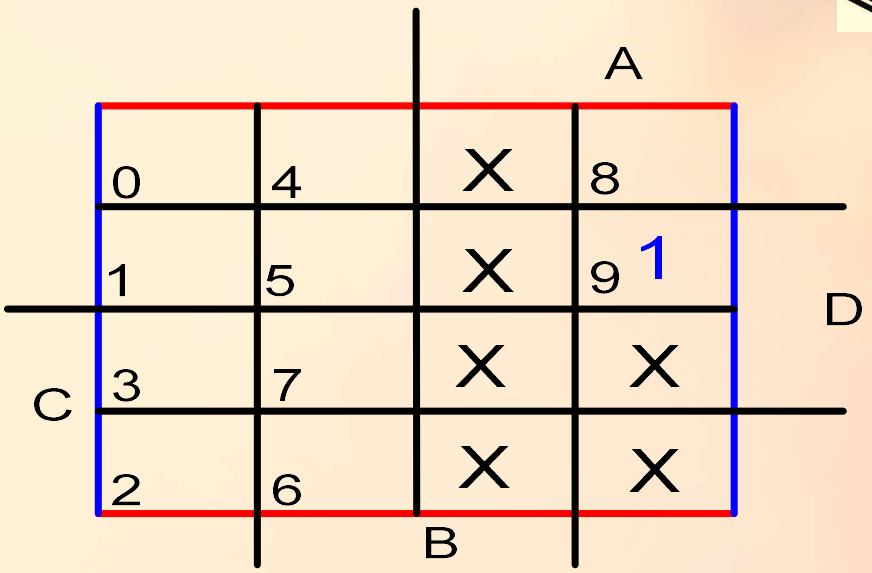
DESIGN OF COUNT UP BCD COUNTER WITH JK-MS-FF

JD=∑m(0,2,4,6,8)=D’
KD=∑m(1,3,5,7,9)=D
JC=∑m(1,5)=A’C’D
KC=∑m(3,7)=CD
JB=∑m(3)=B’CD
KB=∑m(7)=BCD
JA=∑m(7)=BCD
KA=∑m(9)=



DESIGN OF COUNT UP BCD COUNTER WITH JK-MS-FF

JD=∑m(0,2,4,6,8)=D’
KD=∑m(1,3,5,7,9)=D
JC=∑m(1,5)=A’C’D
KC=∑m(3,7)=CD
JB=∑m(3)=B’CD
KB=∑m(7)=BCD
JA=∑m(7)=BCD
KA=∑m(9)=AD



DESIGN OF COUNT UP BCD COUNTER WITH JK-MS-FF

JD=∑m(0,2,4,6,8)=D’
KD=∑m(1,3,5,7,9)=D
JC=∑m(1,5)=A’C’D
KC=∑m(3,7)=CD
JB=∑m(3)=B’CD
KB=∑m(7)=BCD
JA=∑m(7)=BCD
KA=∑m(9)=AD

Without Simplification
JK-MS-FF

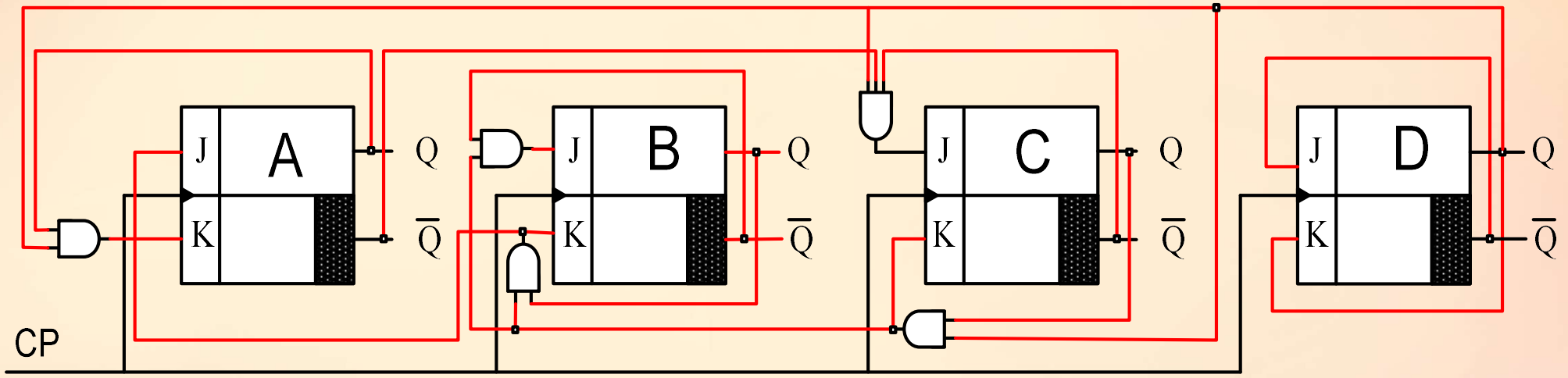
DESIGN OF COUNT UP BCD COUNTER WITH JK-MS-FF

JD=∑m(0,2,4,6,8)=D'=1
KD=∑m(1,3,5,7,9)=D=1
JC=∑m(1,5)=A'C'D=A'D
KC=∑m(3,7)=CD=D
JB=∑m(3)=B'CD=CD
KB=∑m(7)=BCD=CD
JA=∑m(7)=BCD
KA=∑m(9)=AD=D

With simplification JK-MS_FF

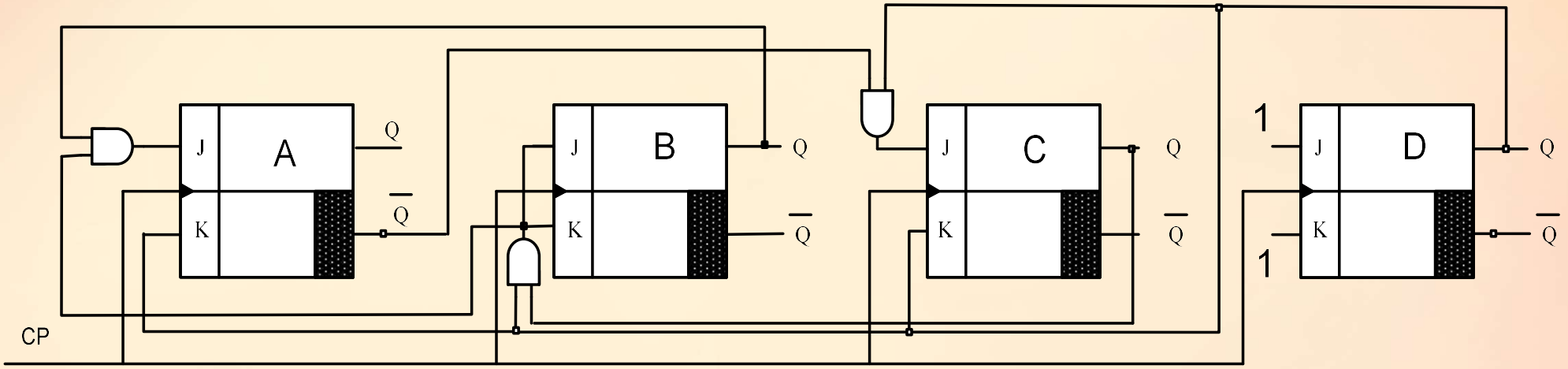
DESIGN OF COUNT UP BCD COUNTER WITH JK-MS-FF

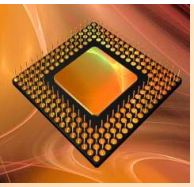
Without Simplification
JK_MS_FF



DESIGN OF COUNT UP BCD COUNTER WITH JK-MS-FF

With simplification JK-MS-FF

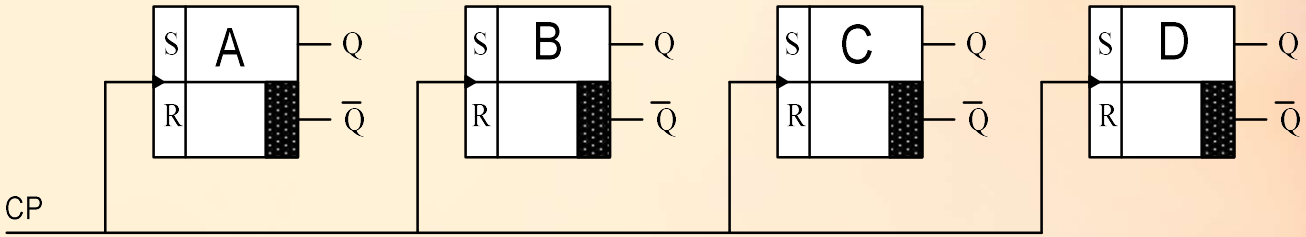




DESIGN OF COUNT UP BCD COUNTER WITH SR-FF

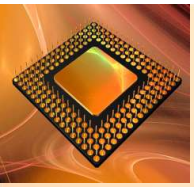
DESIGN OF COUNT UP BCD COUNTER WITH SR-FF

BCD				
	A	B	C	D
0	0	0	0	0
1	0	0	0	1
2	0	0	1	0
3	0	0	1	1
4	0	1	0	0
5	0	1	0	1
6	0	1	1	0
7	0	1	1	1
8	1	0	0	0
9	1	0	0	1
0	0	0	0	0



$Si=\sum m(\ 0 \Rightarrow 1)$

$Ri=\sum m(\ 1 \Rightarrow 0)$

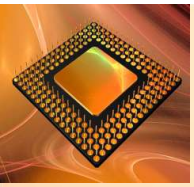


DESIGN OF COUNT UP BCD COUNTER WITH SR-FF

$S_D=\sum m(0,2,4,6,8)=$
$R_D=\sum m(1,3,5,7,9)=$
$S_C=\sum m(1,5)=$
$R_C=\sum m(3,7)=$
$S_B=\sum m(3)=$
$R_B=\sum m(7)=$
$S_A=\sum m(7)=$
$R_A=\sum m(9)=$

DESIGN OF COUNT UP BCD COUNTER WITH SR-FF

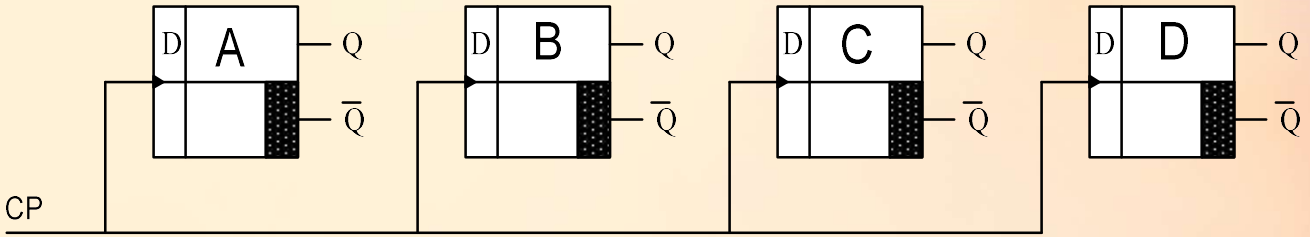
$S_D=\sum m(0,2,4,6,8)=D'$
$R_D=\sum m(1,3,5,7,9)=D$
$S_C=\sum m(1,5)=A'C'D$
$R_C=\sum m(3,7)=CD$
$S_B=\sum m(3)=B'CD$
$R_B=\sum m(7)=BCD$
$S_A=\sum m(7)=BCD$
$R_A=\sum m(9)=AD$



DESIGN OF COUNT UP BCD COUNTER WITH D-FF

DESIGN OF COUNT UP BCD COUNTER WITH D-FF

	BCD			
	A	B	C	D
0	0	0	0	0
1	0	0	0	1
2	0	0	1	0
3	0	0	1	1
4	0	1	0	0
5	0	1	0	1
6	0	1	1	0
7	0	1	1	1
8	1	0	0	0
9	1	0	0	1
0	0	0	0	0



$$Di=\sum m(\ 0 \Rightarrow 1\ \ \&\ \ 1 \Rightarrow 1\ )$$

DESIGN OF COUNT UP BCD COUNTER WITH D-FF

BCD				
	A	B	C	D
0	0	0	0	0
1	0	0	0	1
2	0	0	1	0
3	0	0	1	1
4	0	1	0	0
5	0	1	0	1
6	0	1	1	0
7	0	1	1	1
8	1	0	0	0
9	1	0	0	1
0	0	0	0	0

$$D_D = \sum m(\ 0,2,4,6,8\ )$$

DESIGN OF COUNT UP BCD COUNTER WITH D-FF

BCD				
	A	B	C	D
0	0	0	0	0
1	0	0	0	1
2	0	0	1	0
3	0	0	1	1
4	0	1	0	0
5	0	1	0	1
6	0	1	1	0
7	0	1	1	1
8	1	0	0	0
9	1	0	0	1
0	0	0	0	0

$D_D = \sum m(0,2,4,6,8)$

$D_C = \sum m(1,2,5,6)$

DESIGN OF COUNT UP BCD COUNTER WITH D-FF

BCD				
	A	B	C	D
0	0	0	0	0
1	0	0	0	1
2	0	0	1	0
3	0	0	1	1
4	0	1	0	0
5	0	1	0	1
6	0	1	1	0
7	0	1	1	1
8	1	0	0	0
9	1	0	0	1
0	0	0	0	0

$D_D = \sum m(\ 0,2,4,6,8\ )$

$D_C = \sum m(\ 1,2,5,6\ )$

$D_B = \sum m(\ 3,4,5,6\ )$

DESIGN OF COUNT UP BCD COUNTER WITH D-FF

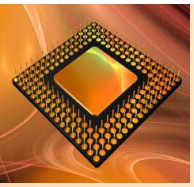
BCD				
	A	B	C	D
0	0	0	0	0
1	0	0	0	1
2	0	0	1	0
3	0	0	1	1
4	0	1	0	0
5	0	1	0	1
6	0	1	1	0
7	0	1	1	1
8	1	0	0	0
9	1	0	0	1
0	0	0	0	0

$D_D = \sum m(0,2,4,6,8)$

$D_C = \sum m(1,2,5,6)$

$D_B = \sum m(3,4,5,6)$

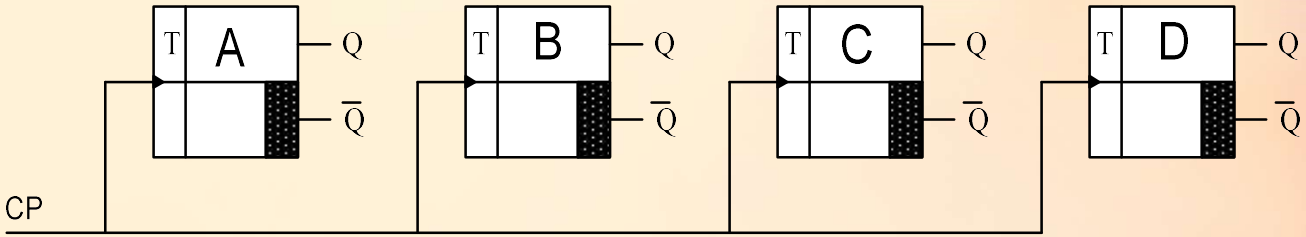
$D_A = \sum m(7,8)$



DESIGN OF COUNT UP BCD COUNTER WITH T-FF

DESIGN OF COUNT UP BCD COUNTER WITH T-FF

	BCD			
	A	B	C	D
0	0	0	0	0
1	0	0	0	1
2	0	0	1	0
3	0	0	1	1
4	0	1	0	0
5	0	1	0	1
6	0	1	1	0
7	0	1	1	1
8	1	0	0	0
9	1	0	0	1
0	0	0	0	0



$$Ti=\sum m(\ 0 \Rightarrow 1\ \ \&\ \ 1 \Rightarrow 0\ )$$

DESIGN OF COUNT UP BCD COUNTER WITH T-FF

BCD				
	A	B	C	D
0	0	0	0	0
1	0	0	0	1
2	0	0	1	0
3	0	0	1	1
4	0	1	0	0
5	0	1	0	1
6	0	1	1	0
7	0	1	1	1
8	1	0	0	0
9	1	0	0	1
0	0	0	0	0

$$T_D = \sum m(0,1,2,3,4,5,6,7,8,9)$$

DESIGN OF COUNT UP BCD COUNTER WITH T-FF

BCD				
	A	B	C	D
0	0	0	0	0
1	0	0	0	1
2	0	0	1	0
3	0	0	1	1
4	0	1	0	0
5	0	1	0	1
6	0	1	1	0
7	0	1	1	1
8	1	0	0	0
9	1	0	0	1
0	0	0	0	0

$T_D = \sum m(0,1,2,3,4,5,6,7,8,9)$

$T_C = \sum m(1,3,5,7)$

DESIGN OF COUNT UP BCD COUNTER WITH T-FF

BCD				
	A	B	C	D
0	0	0	0	0
1	0	0	0	1
2	0	0	1	0
3	0	0	1	1
4	0	1	0	0
5	0	1	0	1
6	0	1	1	0
7	0	1	1	1
8	1	0	0	0
9	1	0	0	1
0	0	0	0	0

$T_D = \sum m(0,1,2,3,4,5,6,7,8,9)$

$T_C = \sum m(1,3,5,7)$

$T_B = \sum m(3,7)$

DESIGN OF COUNT UP BCD COUNTER WITH T-FF

BCD				
	A	B	C	D
0	0	0	0	0
1	0	0	0	1
2	0	0	1	0
3	0	0	1	1
4	0	1	0	0
5	0	1	0	1
6	0	1	1	0
7	0	1	1	1
8	1	0	0	0
9	1	0	0	1
0	0	0	0	0

$T_D = \sum m(0,1,2,3,4,5,6,7,8,9)$

$T_C = \sum m(1,3,5,7)$

$T_B = \sum m(3,7)$

$T_A = \sum m(7,9)$

DESIGN OF COUNT UP BCD COUNTER WITH T-FF

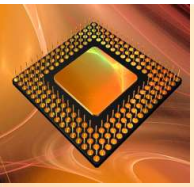
BCD				
	A	B	C	D
0	0	0	0	0
1	0	0	0	1
2	0	0	1	0
3	0	0	1	1
4	0	1	0	0
5	0	1	0	1
6	0	1	1	0
7	0	1	1	1
8	1	0	0	0
9	1	0	0	1
0	0	0	0	0

$T_D = \sum m(0,1,2,3,4,5,6,7,8,9)$

$T_C = \sum m(1,3,5,7)$

$T_B = \sum m(3,7)$

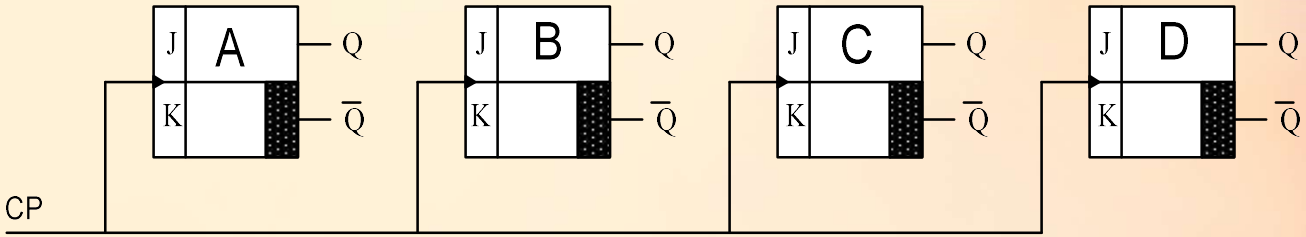
$T_A = \sum m(7,9)$



DESIGN OF COUNT DOWN BCD COUNTER WITH SR-FF

ESIGN OF COUNT DOWN BCD COUNTER WITH JK-MS-FF

BCD				
	A	B	C	D
9	1	0	0	1
8	1	0	0	0
7	0	1	1	1
6	0	1	1	0
5	0	1	0	1
4	0	1	0	0
3	0	0	1	1
2	0	0	1	0
1	0	0	0	1
0	0	0	0	0
9	1	0	0	1

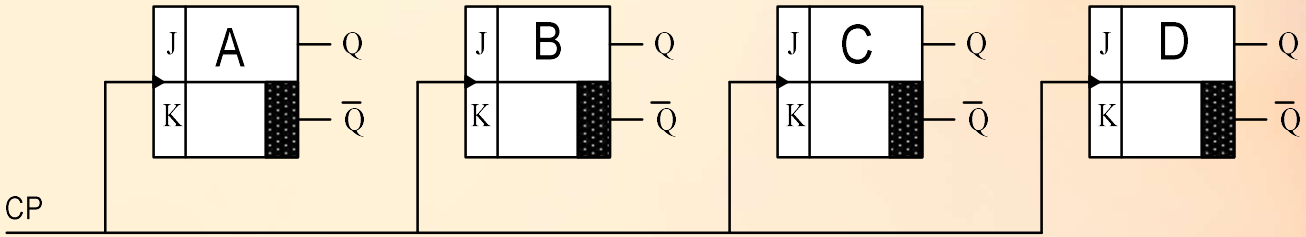


$Ji=\sum m(\ 0 \Rightarrow 1)$

$Ki=\sum m(\ 1 \Rightarrow 0)$

DESIGN OF COUNT DOWN BCD COUNTER WITH JK-MS-FF

BCD				
	A	B	C	D
9	1	0	0	1
8	1	0	0	0
7	0	1	1	1
6	0	1	1	0
5	0	1	0	1
4	0	1	0	0
3	0	0	1	1
2	0	0	1	0
1	0	0	0	1
0	0	0	0	0
9	1	0	0	1

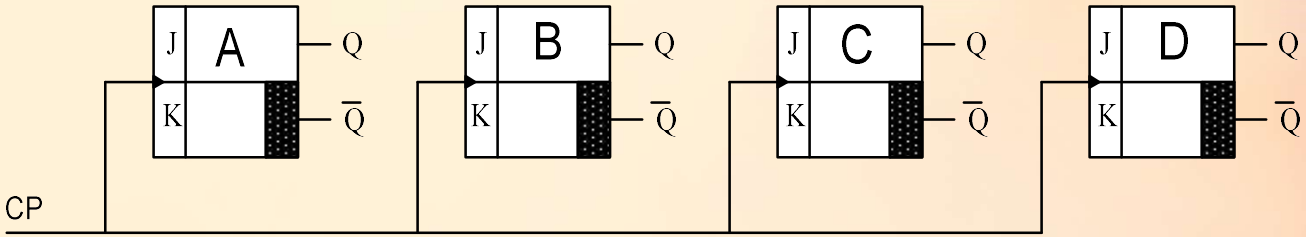


$Ji=\sum m(\ 0 \Rightarrow 1)$

$Ki=\sum m(\ 1 \Rightarrow 0)$

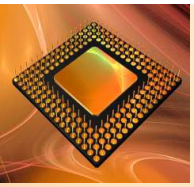
DESIGN OF COUNT DOWN BCD COUNTER WITH JK-MS-FF

	BCD			
	A	B	C	D
9	1	0	0	1
8	1	0	0	0
7	0	1	1	1
6	0	1	1	0
5	0	1	0	1
4	0	1	0	0
3	0	0	1	1
2	0	0	1	0
1	0	0	0	1
0	0	0	0	0
9	1	0	0	1

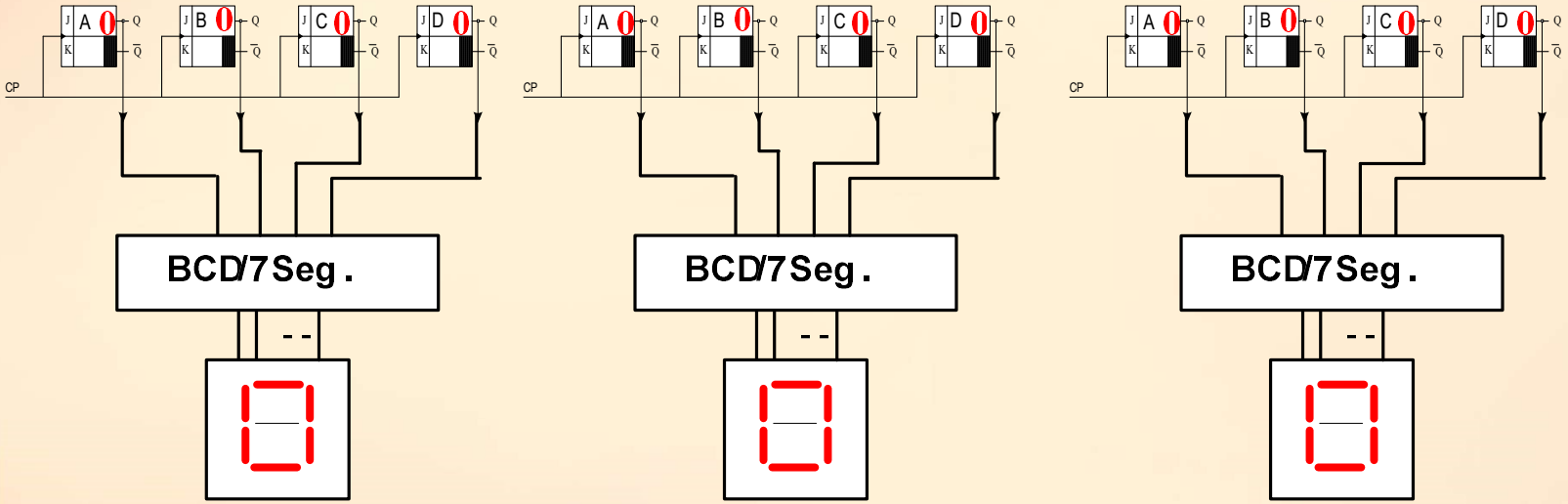


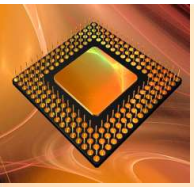
$Ji=\sum m(\ 0 \Rightarrow 1)$

$Ki=\sum m(\ 1 \Rightarrow 0)$

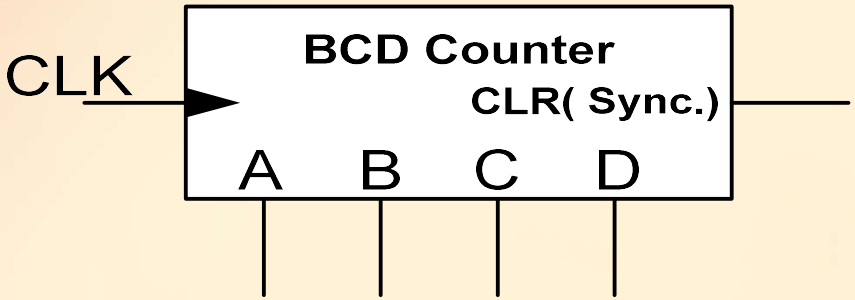


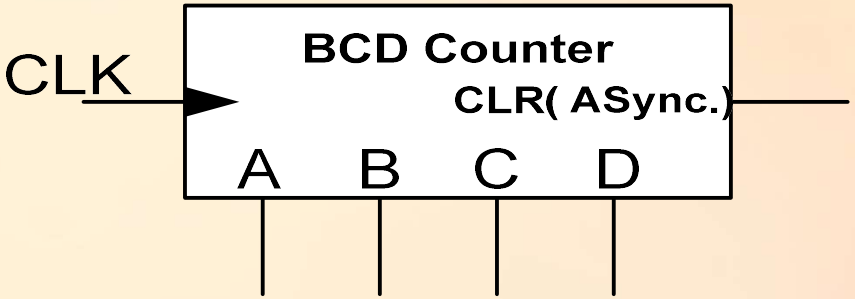
	BCD			
	A	B	C	
0	0	0	0	
1	0	0	0	1
2	0	0	1	0
3	0	0	1	1
4	0	1	0	0
5	0	1	0	1
6	0	1	1	0
7	0	1	1	1
8	1	0	0	0
9	1	0	0	1
0	0	0	0	0

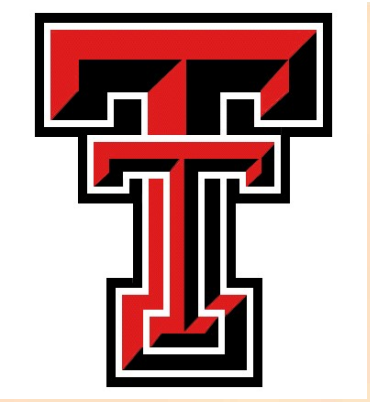


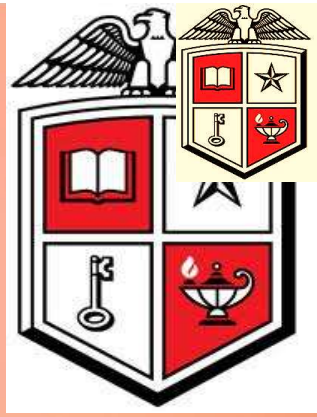


Design of frequency dividers with BCD Counters
Design of other counters with BCD Counters









Thank You