Modern Digital System Design

ECE 2372 / Fall 2018 / Lecture 10

Texas Tech University
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Coding

Binary-coded decimal

2^3	2^2	2^1	2^0
A	B	C	D

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

Binary-coded decimal

2	4	2	1
A	B	C	D

Aiken				
	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	1	0	1	1
6	1	1	0	0
7	1	1	0	1
8	1	1	1	0
9	1	1	1	1

2^3	2^2	2^1	2^0
A	B	C	D

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

Aiken

	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	1	0	1	1
6	1	1	0	0
7	1	1	0	1
8	1	1	1	0
9	1	1	1	1

self-complementary

2	4	2	1
A	B	C	D

Aiken

	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	1	0	1	1
6	1	1	0	0
7	1	1	0	1
8	1	1	1	0
9	1	1	1	1

self-complementary

2	4	2	1
A	B	C	D

Aiken

	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	1	0	1	1
6	1	1	0	0
7	1	1	0	1
8	1	1	1	0
9	1	1	1	1

2	4	2	1
A	B	C	D

Aiken

	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	1	0	1	1
6	1	1	0	0
7	1	1	0	1
8	1	1	1	0
9	1	1	1	1

2	4	2	1
A	B	C	D

self-complementary

	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	1	0	1	1
6	1	1	0	0
7	1	1	0	1
8	1	1	1	0
9	1	1	1	1

2	4	2	1
A	B	C	D

A	B	C	D

Excess _3				
	A	B	C	D
0	0	0	1	1
1	0	1	0	0
2	0	1	0	1
3	0	1	1	0
4	0	1	1	1
5	1	0	0	0
6	1	0	0	1
7	1	0	1	0
8	1	0	1	1
9	1	1	0	0

2^3	2^2	2^1	2^0
A	B	C	D

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

self-complementary

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

self-complementary

self-complementary

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

self-complementary

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

self-complementary

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

self-complementary

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

Johnson Code

A	B	C	D

Johnson					
	A	B	C	D	**E**
0	**0**	**0**	**0**	**0**	**0**
1	**0**	**0**	**0**	**0**	**1**
2	**0**	**0**	**0**	**1**	**1**
3	**0**	**0**	**1**	**1**	**1**
4	**0**	**1**	**1**	**1**	**1**
5	**1**	**1**	**1**	**1**	**1**
6	**1**	**1**	**1**	**1**	**0**
7	**1**	**1**	**1**	**0**	**0**
8	**1**	**1**	**0**	**0**	**0**
9	**1**	**0**	**0**	**0**	**0**

2_Out_of_5

	A	B	C	D	E
2_Out_of_5					
	A	B	C	D	**E**
0	**1**	**1**	**0**	**0**	**0**
1	**0**	**0**	**0**	**1**	**1**
2	**0**	**0**	**1**	**0**	**1**
3	**0**	**0**	**1**	**1**	**0**
4	**0**	**1**	**0**	**0**	**1**
5	**0**	**1**	**0**	**1**	**0**
6	**0**	**1**	**1**	**0**	**0**
7	**1**	**0**	**0**	**0**	**1**
8	**1**	**0**	**0**	**1**	**0**
9	**1**	**0**	**1**	**0**	**0**

Gray Code

Gray				
	A	B	C	D
0	0	0	0	0
1	0	0	0	1
2	0	0	1	1
3	0	0	1	0
4	0	1	1	0
5	0	1	1	1
6	0	1	0	1
7	0	1	0	0
8	1	1	0	0
9	1	1	0	1
10	1	1	1	1
11	1	1	1	0
12	1	0	1	0
13	1	0	1	1
14	1	0	0	1
15	1	0	0	0

K_map for BCD, EX-3 and Aiken

BCD

CD \ AB	00	01	11	10
00	0	4	x	8
01	1	5	x	9
11	3	7	x	x
10	2	6	x	x

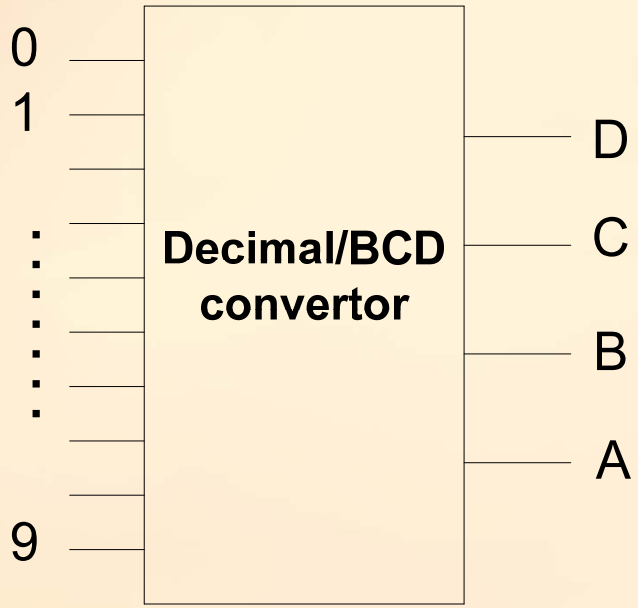
Aiken

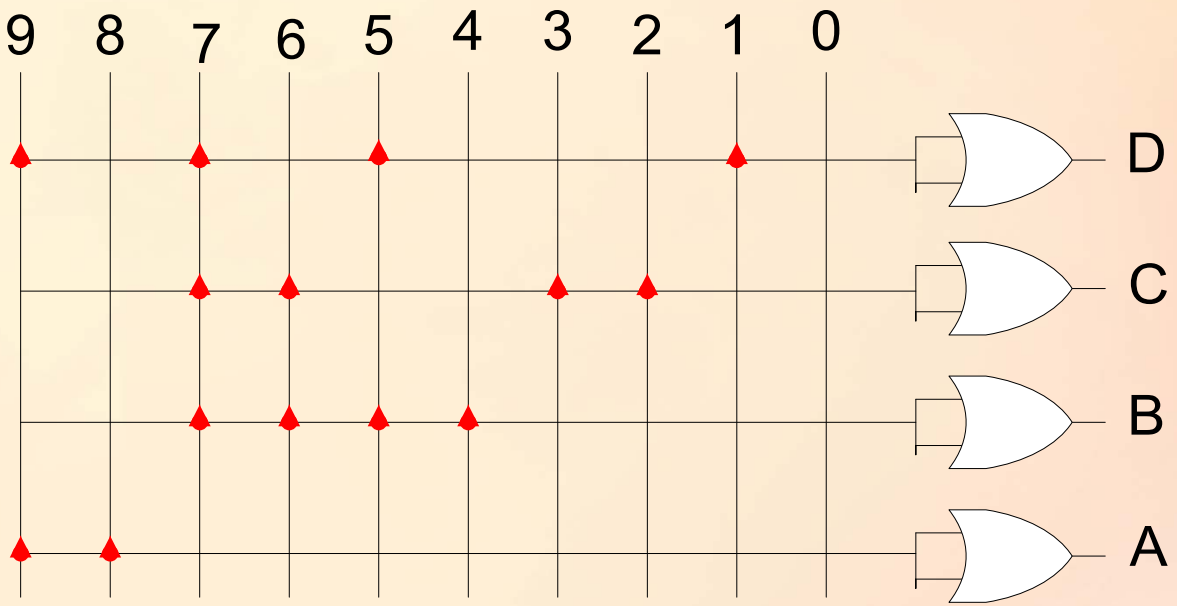
CD \ AB	00	01	11	10
00	0	4	6	x
01	1	x	7	x
11	3	x	9	5
10	2	x	8	x

Ex-3

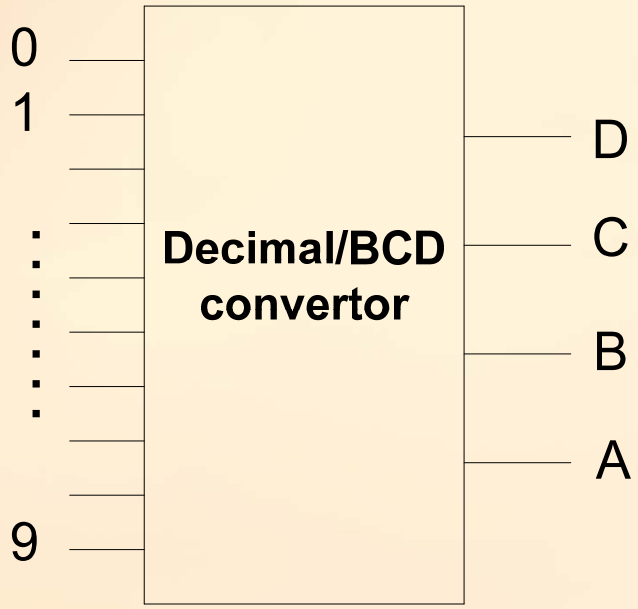
CD \ AB	00	01	11	10
00	x	1	9	5
01	x	2	x	6
11	0	4	x	8
10	x	3	x	7

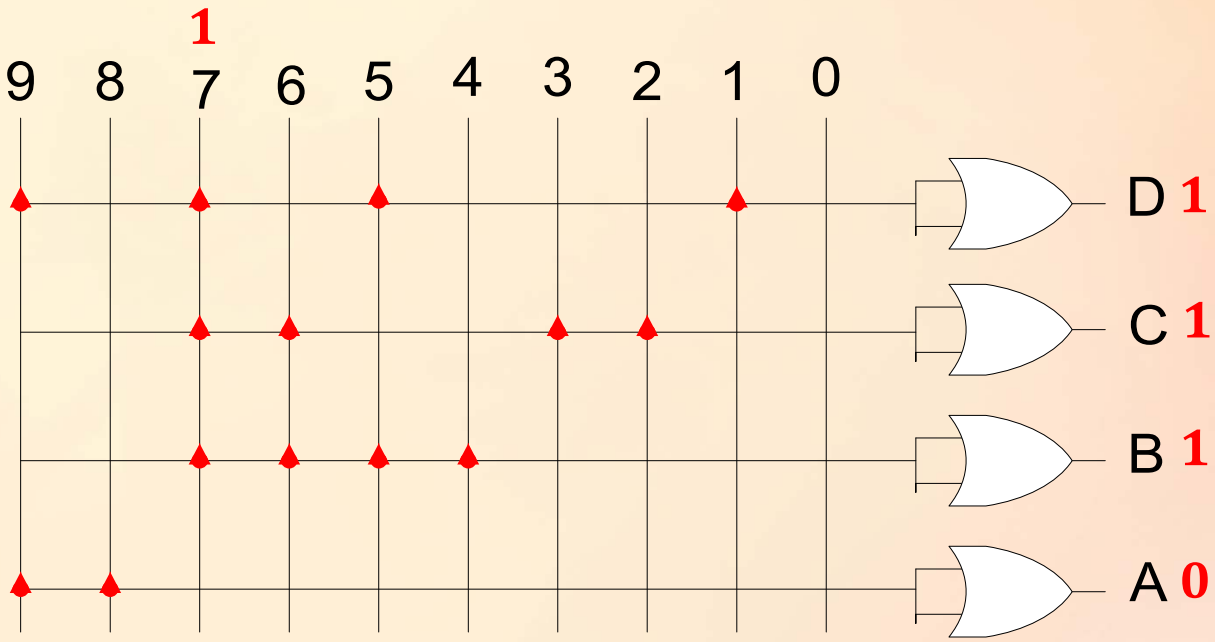
Decimal to BCD Convertor



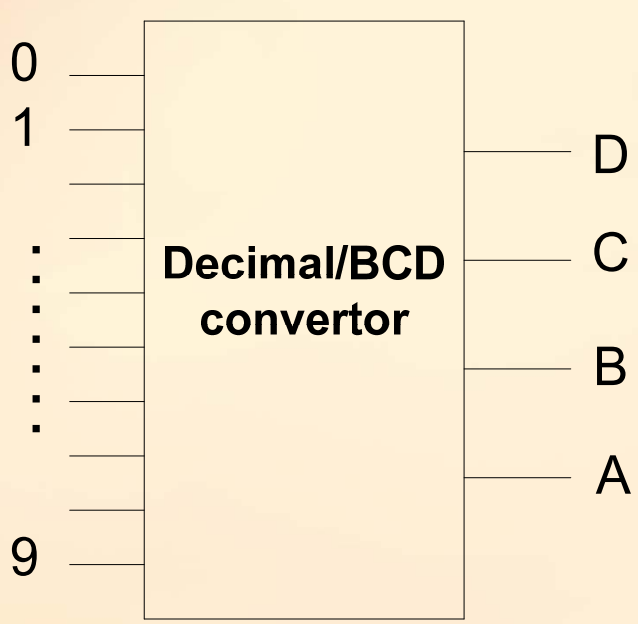


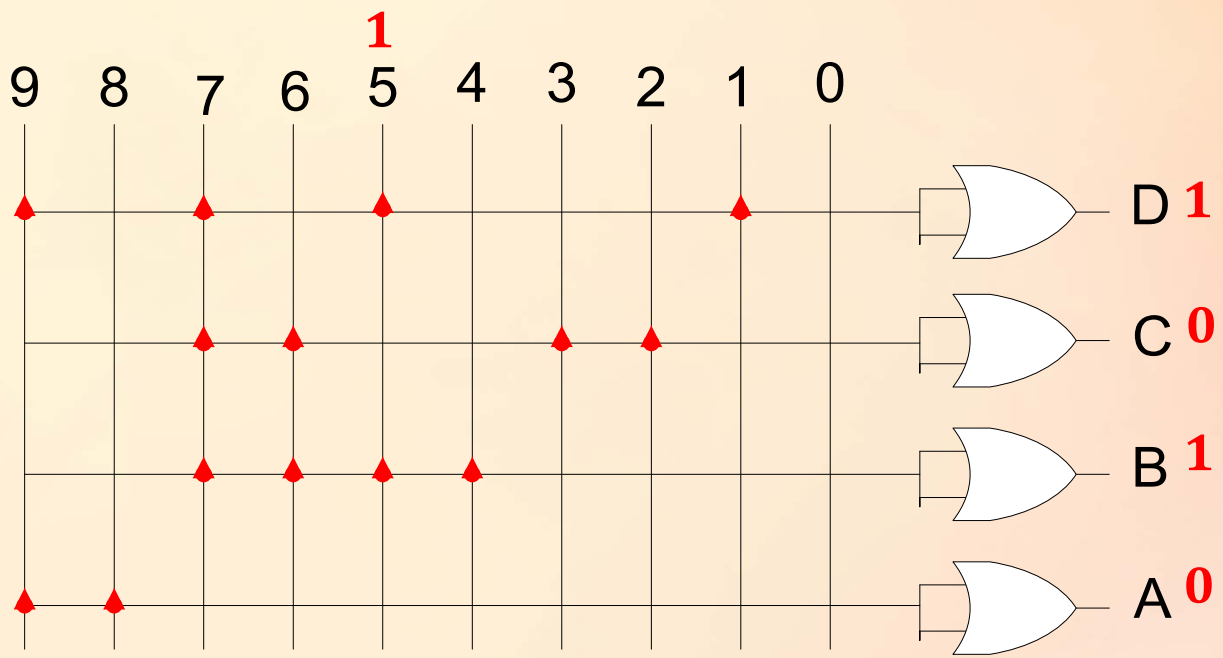
Decimal to BCD Convertor



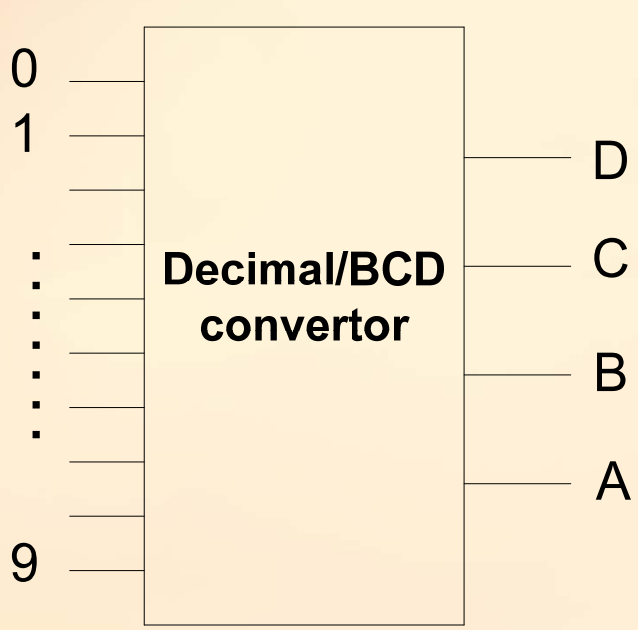


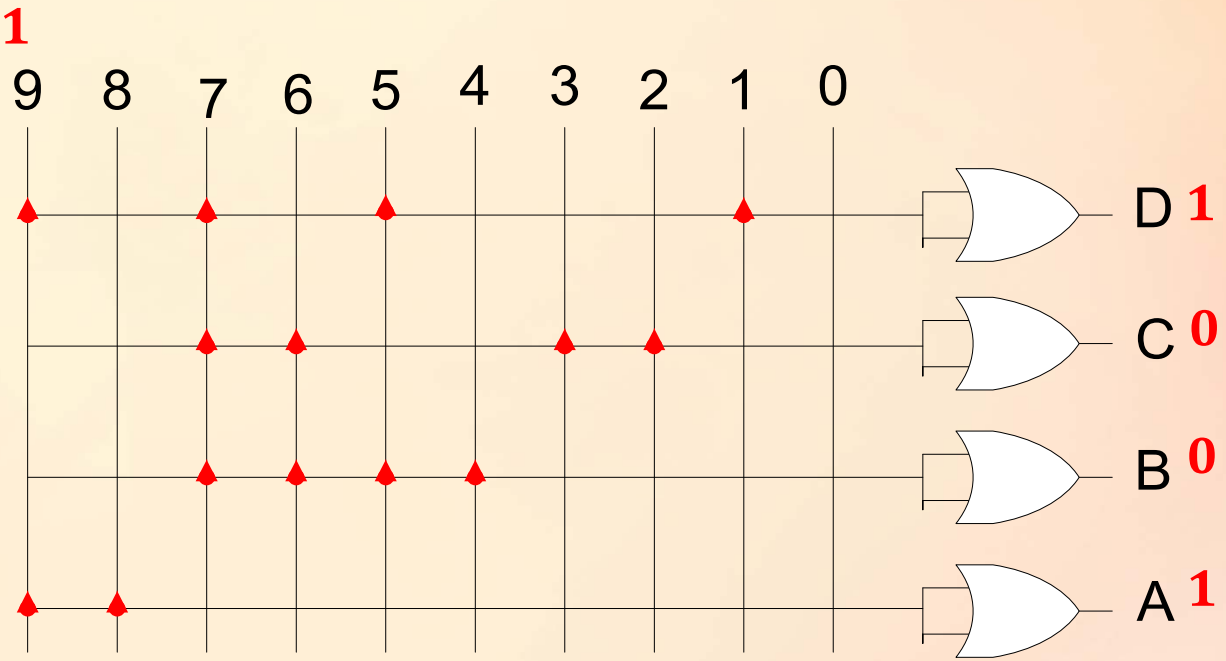
Decimal to BCD Convertor



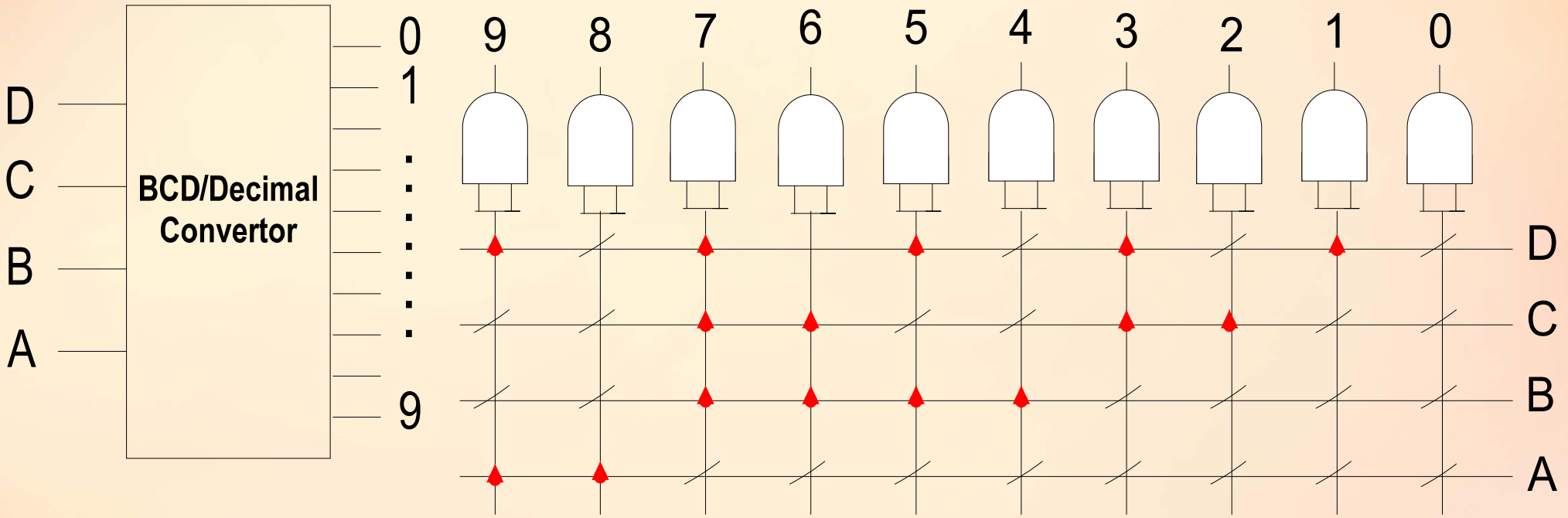


Decimal to BCD Convertor

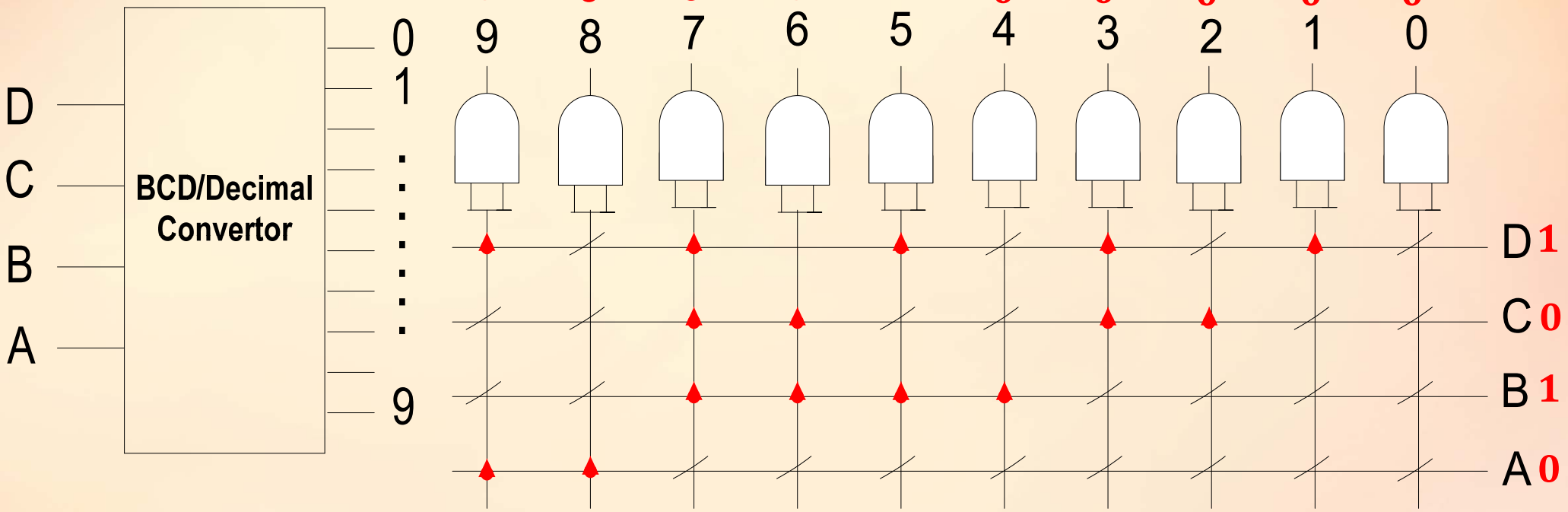




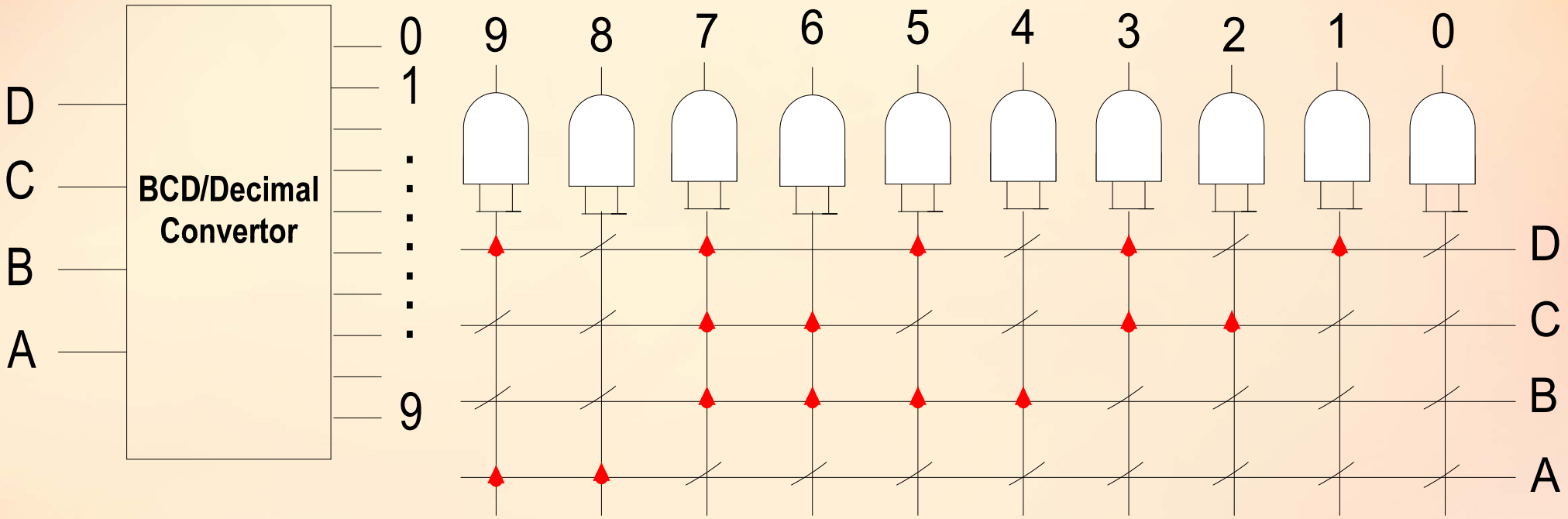
BCD to Decimal Convertor



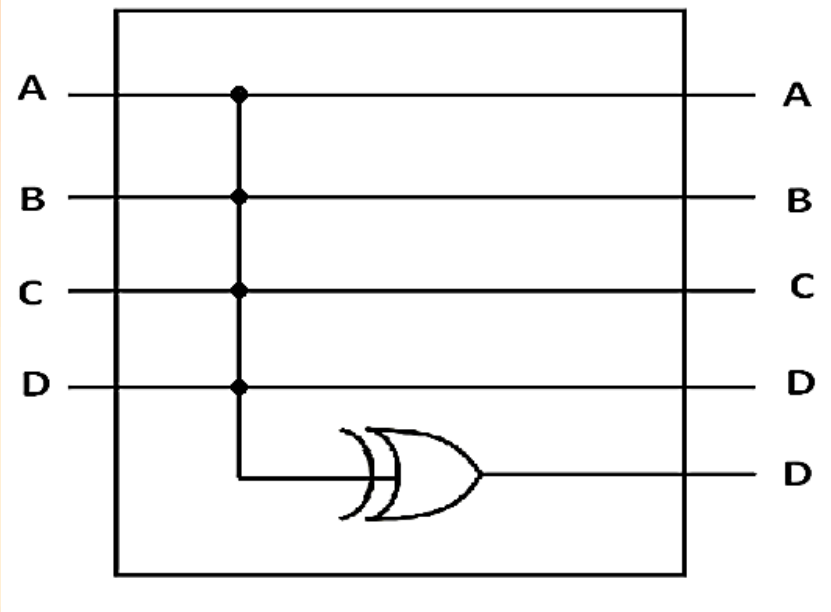
BCD to Decimal Convertor



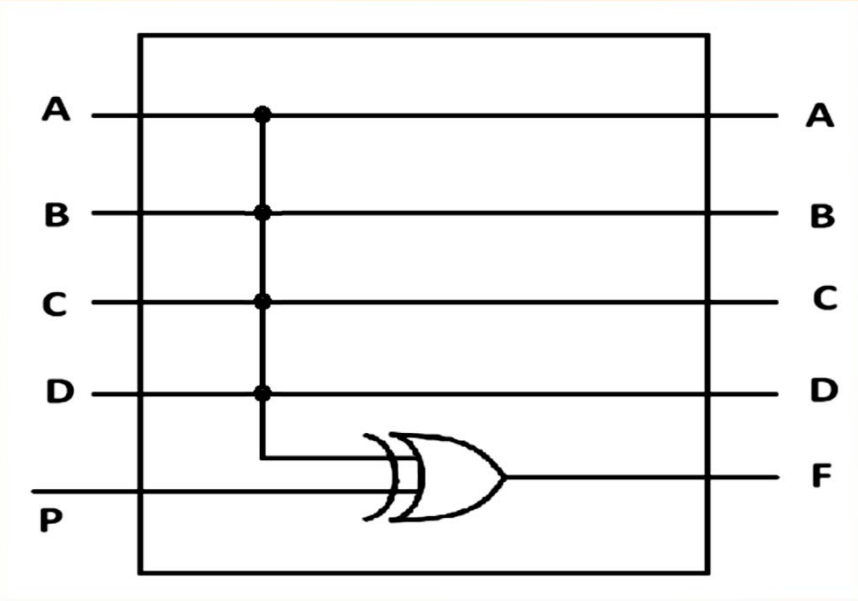
BCD to Decimal Convertor



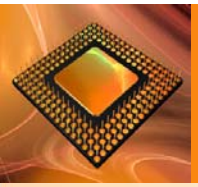
Even Parity



Source Circuit

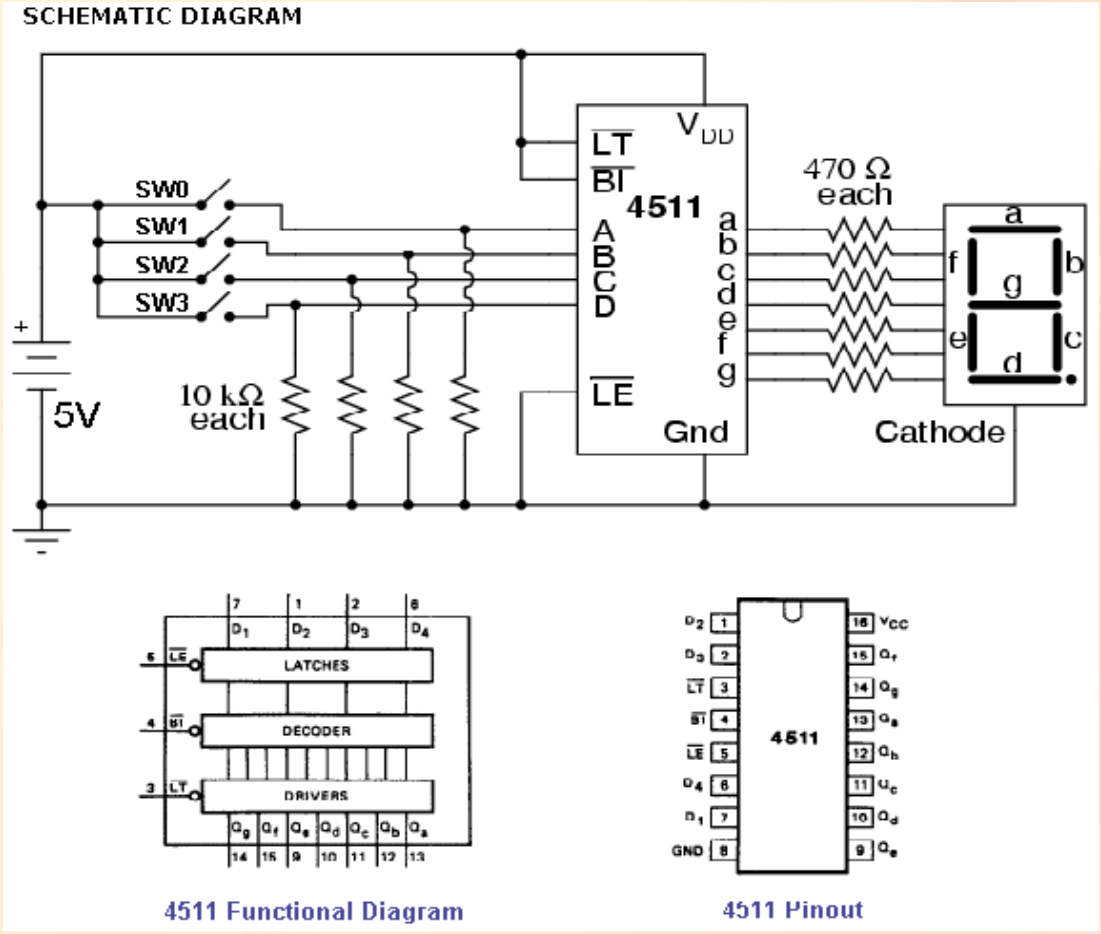


Destination Circuit

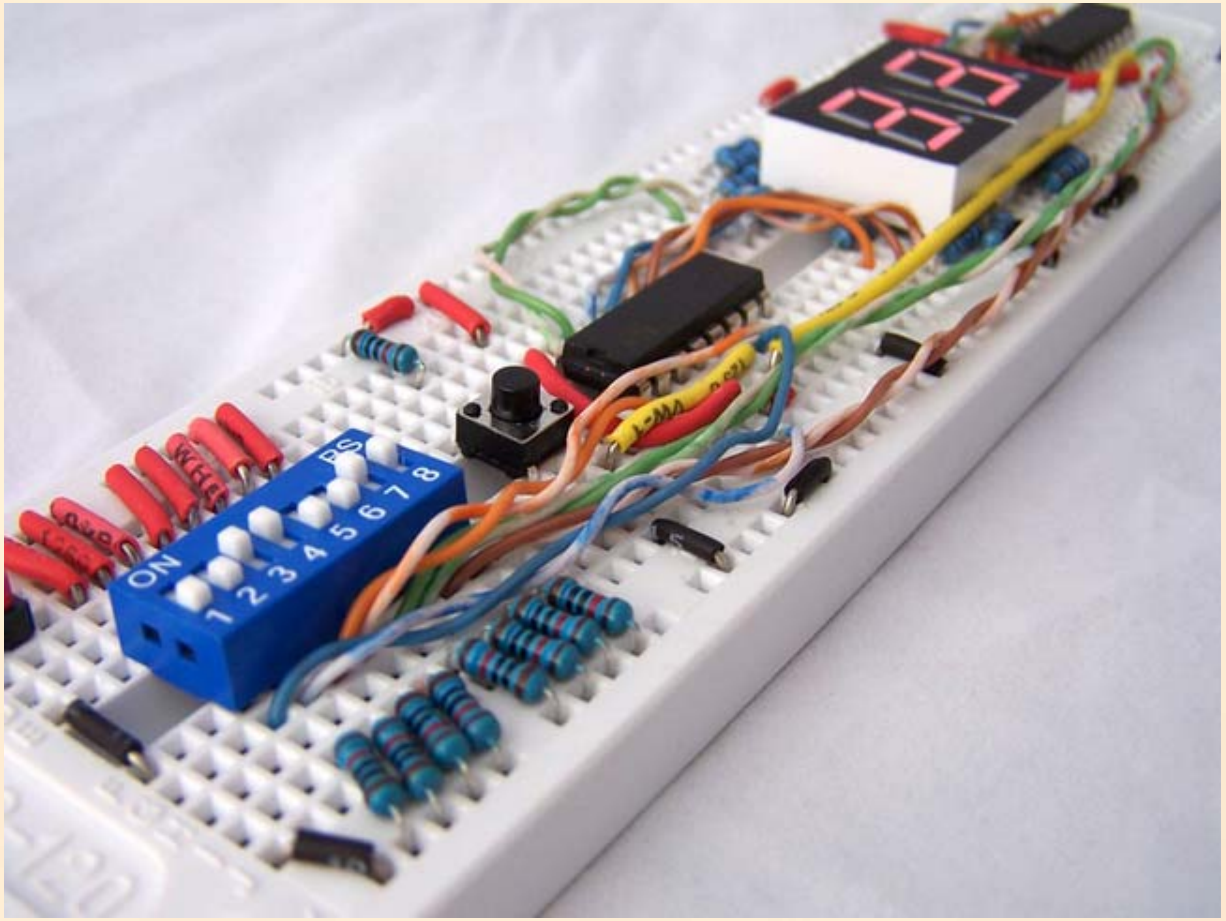


ADD & SUB IN CODE

Input and Output



Sample of Digital Circuit on the breadboard

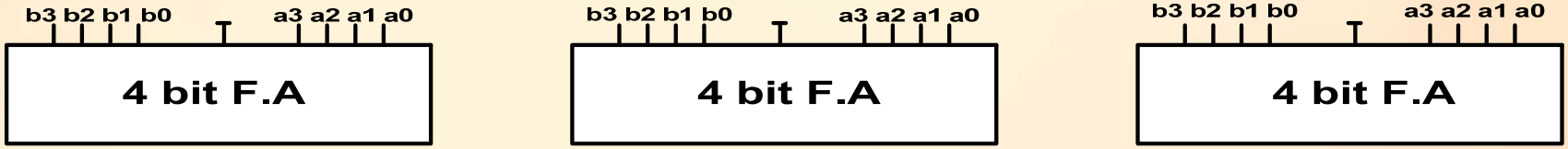


Add in BCD code

A+ A3 A2 A1+
B B3 B2 B1

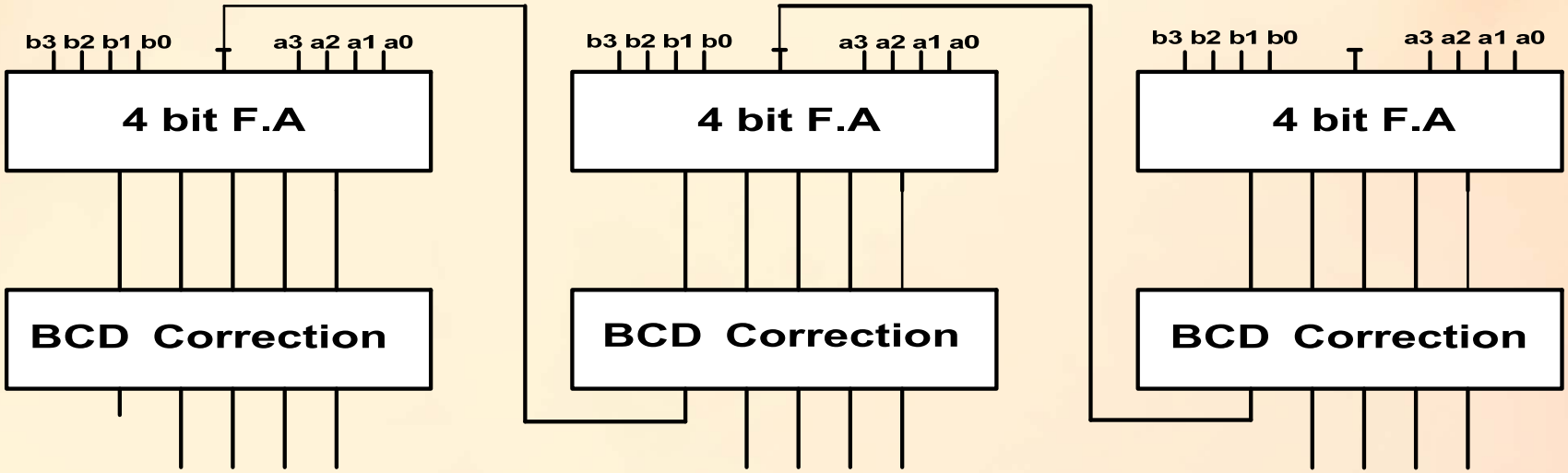
A+
B

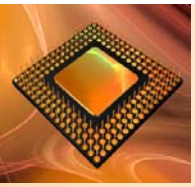
A3 A2 A1+
B3 B2 B1



A+
B

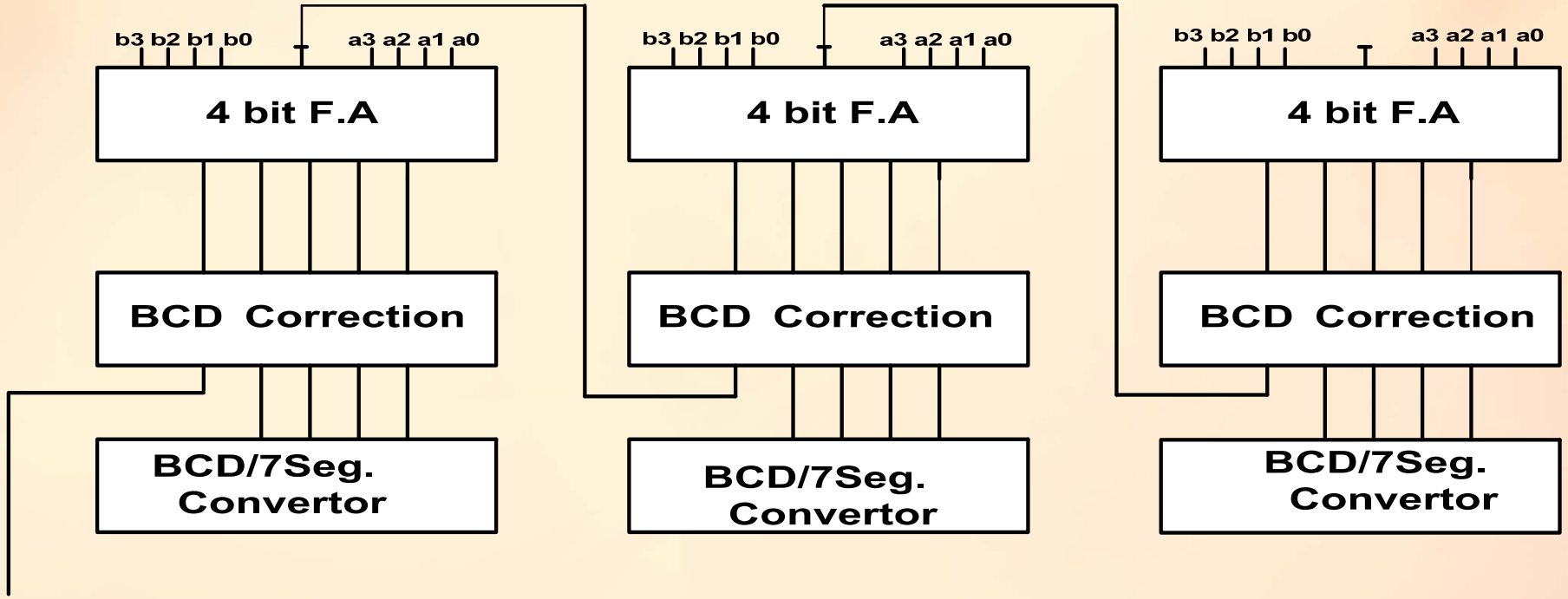
A3 A2 A1+
B3 B2 B1





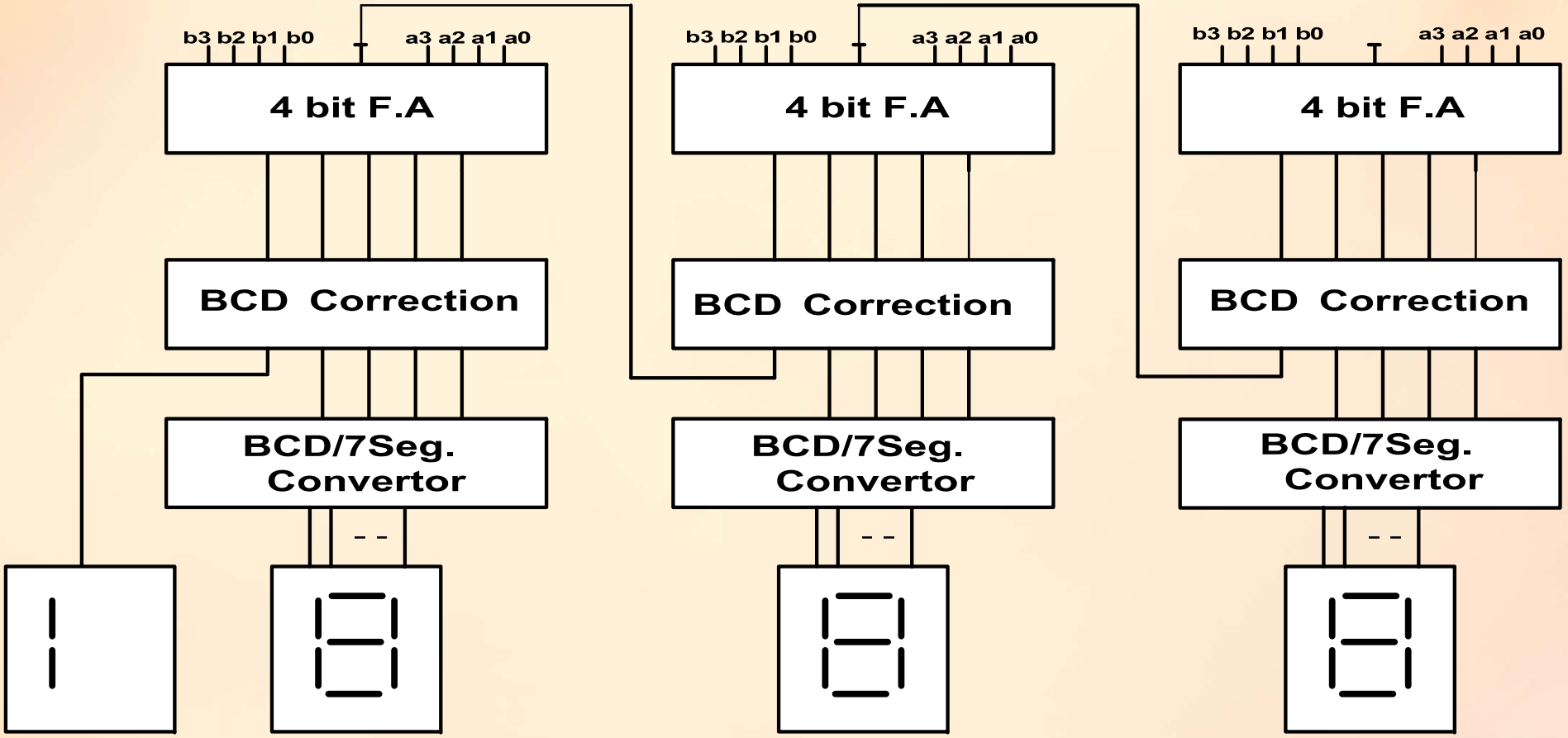
A+
B

A3 A2 A1+
B3 B2 B1

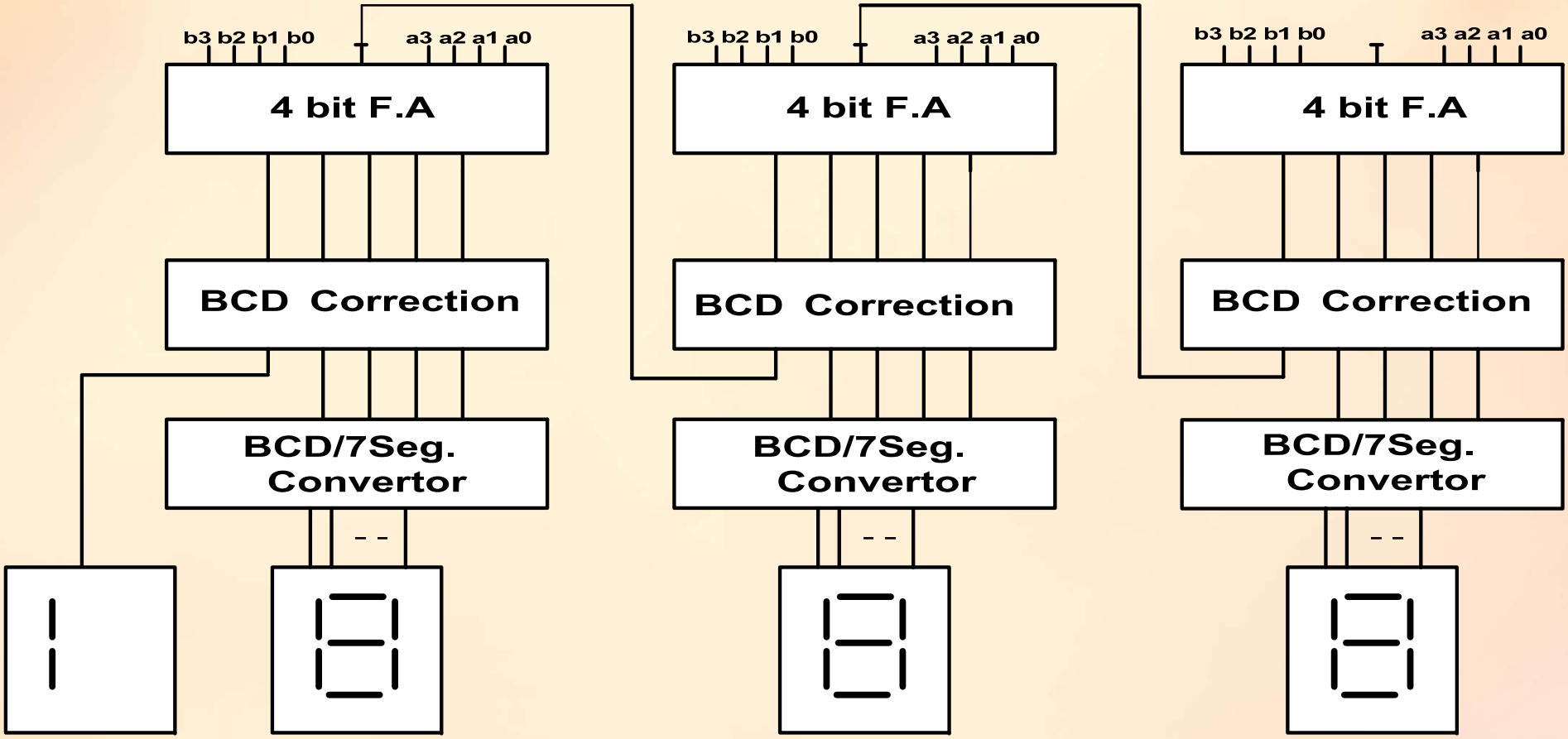


A+
B

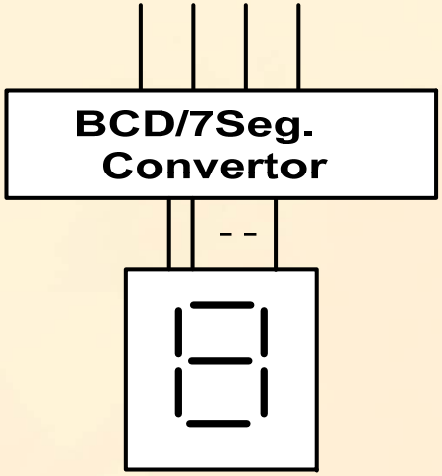
A3 A2 A1+
B3 B2 B1



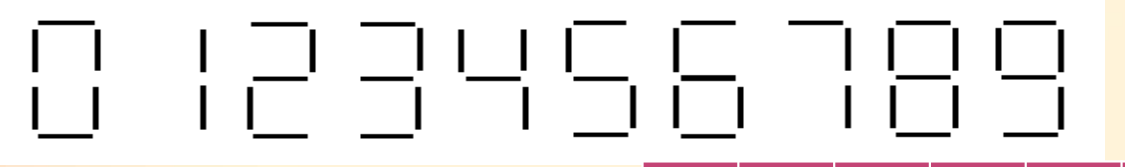
Add in BCD code

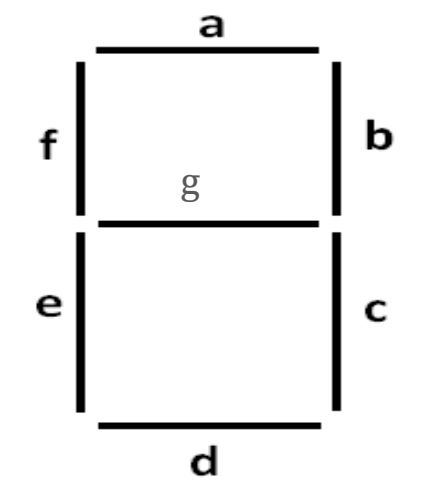


BCD/7Seg. Convertor



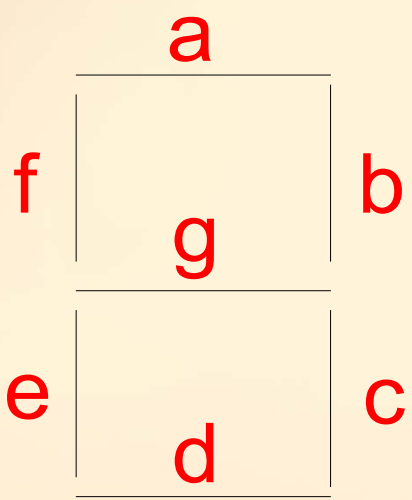
7 Seg.

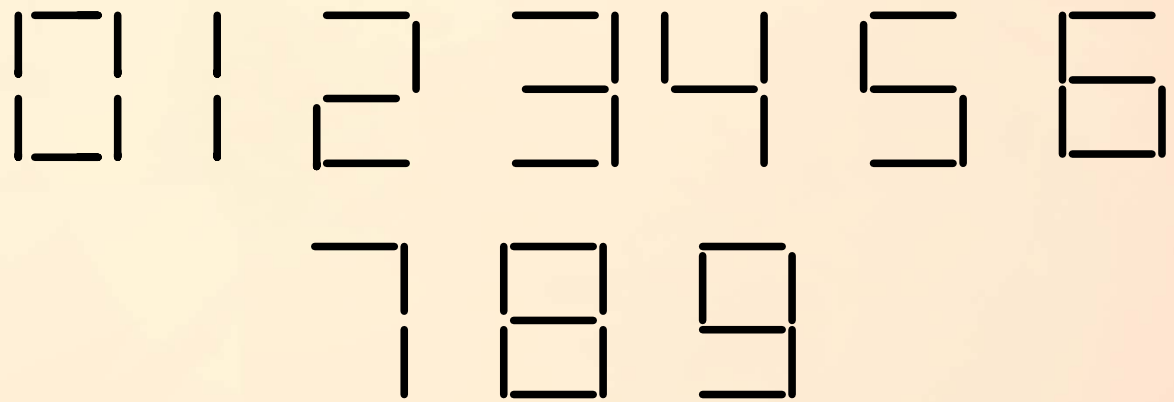


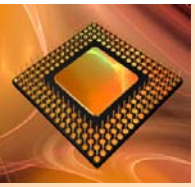


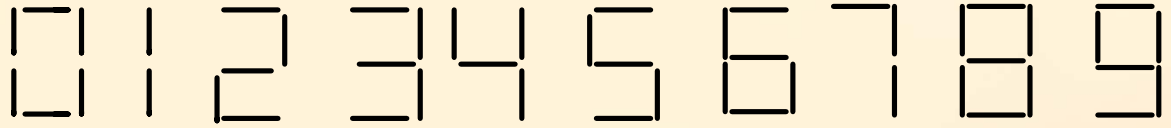
	A	B	C	D	g	f	e	d	c	b	a
0	0	0	0	0	0	1	1	1	1	1	1
1	0	0	0	1	0	0	0	0	1	1	0
2	0	0	1	0	1	0	1	1	0	1	1
3	0	0	1	1	1	0	0	1	1	1	1
4	0	1	0	0	1	1	0	0	1	1	0
5	0	1	0	1	1	1	0	1	1	0	1
6	0	1	1	0	1	1	1	1	1	0	1
7	0	1	1	1	0	0	0	0	1	1	1
8	1	0	0	0	1	1	1	1	1	1	1
9	1	0	0	1	1	1	0	1	1	1	1

Design of BCD/7Seg. Convertor

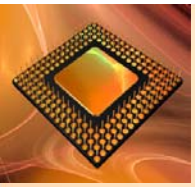


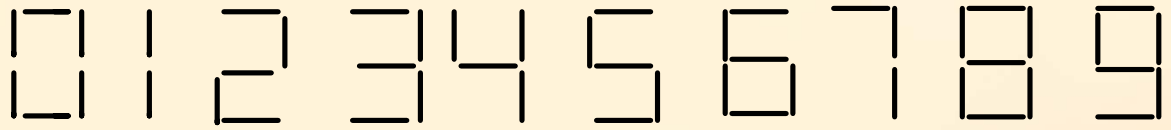




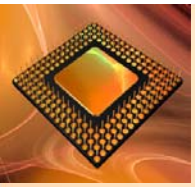


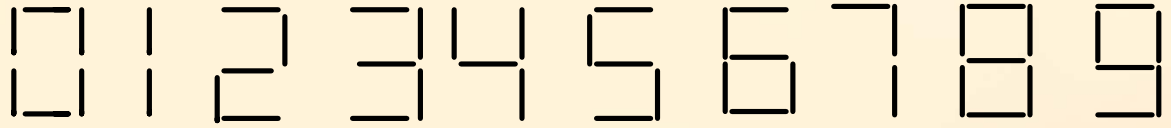
	A	B	C	D	a	b	c	d	e	f	g





	A	B	C	D	a	b	c	d	e	f	g
0	0	0	0	0	1	1	1	1	1	1	0
1	0	0	0	1	0	1	1	0	0	0	0
2	0	0	1	0	1	1	0	1	1	0	1
3	0	0	1	1	1	1	1	1	0	0	1
4	0	1	0	0	0	1	1	0	0	1	1
5	0	1	0	1	1	0	1	1	0	1	1
6	0	1	1	0	1	0	1	1	1	1	1
7	0	1	1	1	1	1	1	0	0	0	0
8	1	0	0	0	1	1	1	1	1	1	1





	A	B	C	D	a	b	c	d	e	f	g
0	0	0	0	0	1	1	1	1	1	1	0
1	0	0	0	1	0	1	1	0	0	0	0
2	0	0	1	0	1	1	0	1	1	0	1
3	0	0	1	1	1	1	1	1	0	0	1
4	0	1	0	0	0	1	1	0	0	1	1
5	0	1	0	1	1	0	1	1	0	1	1
6	0	1	1	0	1	0	1	1	1	1	1
7	0	1	1	1	1	1	1	0	0	0	0
8	1	0	0	0	1	1	1	1	1	1	1
9	1	0	0	1	1	1	1	1	0	1	1

Design of BCD/7Seg. Convertor

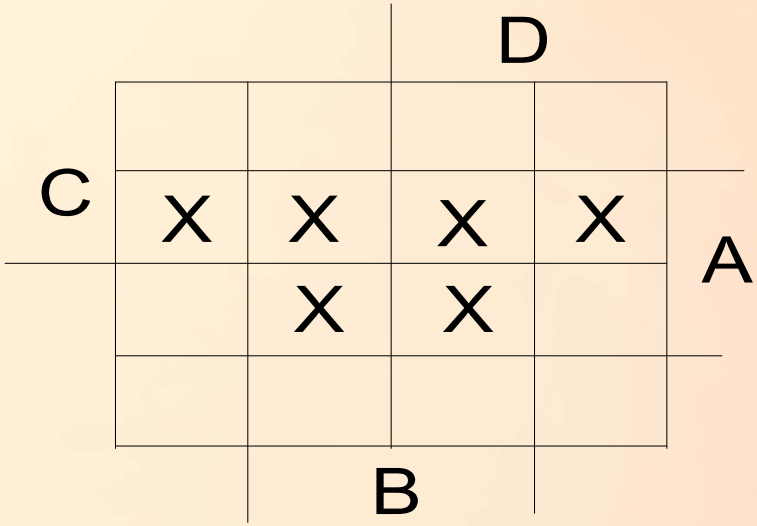
$$a = \sum m(0,2,3,5,6,7,8,9)$$

C \ AB \ D	2	6	7	3
X	X	X	X	X
8	X	X	9	A
0	4	5	1	

B

Design of BCD/7Seg. Convertor

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



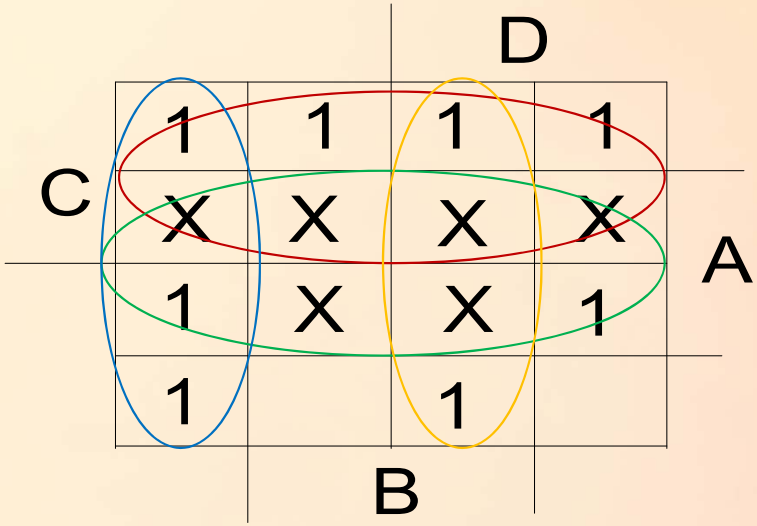
Design of BCD/7Seg. Convertor

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

C \ AB \ D	00	01	11	10
00	1	1	1	1
01	X	X	X	X
11	1	X	X	1
10	1		1	

Design of BCD/7Seg. Convertor

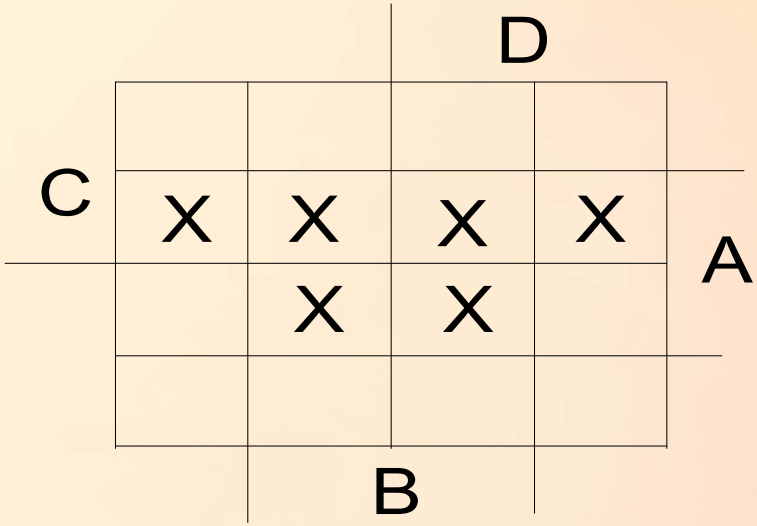
$$a = C + A + \overline{B}\,\overline{D} + BD$$



Design of BCD/7Seg. Convertor

$$a = C + A + \overline{B}\,\overline{D} + BD$$

$$b = \sum m(0,1,3,4,7,8,9)$$



Design of BCD/7Seg. Convertor

$$a = C + A + \overline{B}\,\overline{D} + BD$$

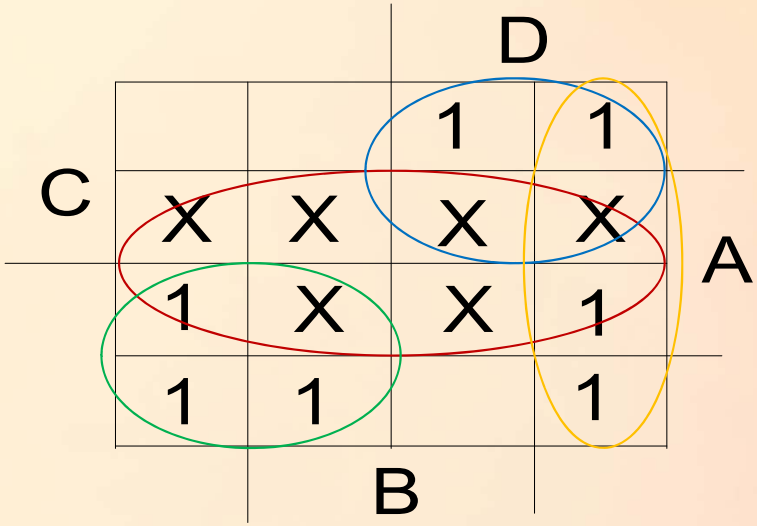
$$b = \sum m(0,1,3,4,7,8,9)$$

C \ AB \ D	00	01	11	10
00			1	1
01	X	X	X	X
11	1	X	X	1
10	1	1		1

Design of BCD/7Seg. Convertor

$$a = C + A + \overline{B}\,\overline{D} + BD$$

$$b = A + CD + \overline{C}\,\overline{D} + \overline{B}D$$

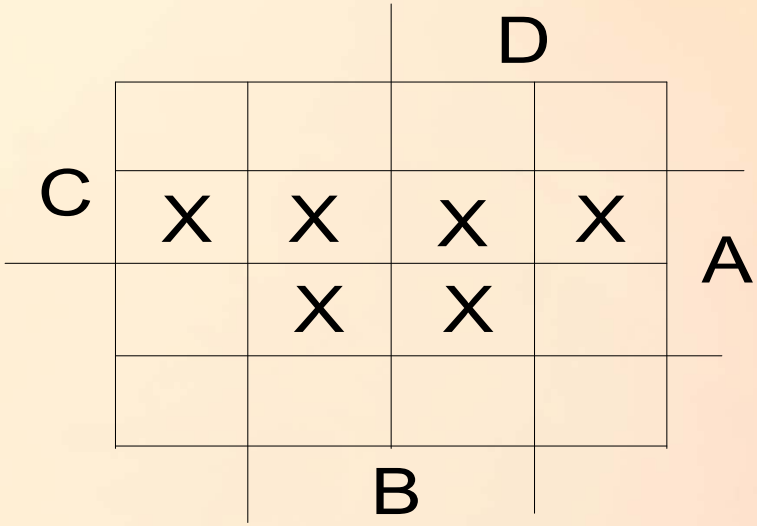


Design of BCD/7Seg. Convertor

$$a = C + A + \overline{B}\,\overline{D} + BD$$

$$b = A + CD + \overline{C}\,\overline{D} + \overline{B}D$$

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



Design of BCD/7Seg. Convertor

$$a = C + A + \overline{B}\,\overline{D} + BD$$

$$b = A + CD + \overline{C}\,\overline{D} + \overline{B}D$$

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

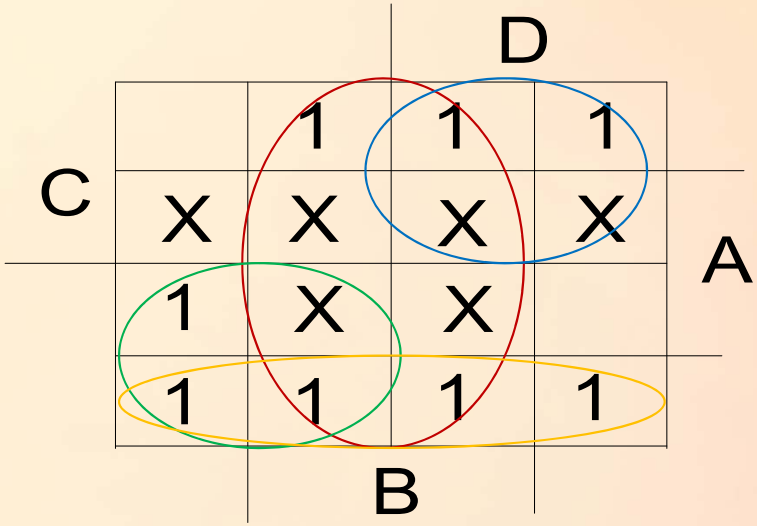
C \ AB \ D		1	1	1
	X	X	X	X
	1	X	X	
	1	1	1	1

Design of BCD/7Seg. Convertor

$$a = C + A + \overline{B}\,\overline{D} + BD$$

$$b = A + CD + \overline{C}\,\overline{D} + B\overline{D}$$

$$c = B + CD + \overline{C}\,\overline{D} + \overline{A}\,\overline{C}$$



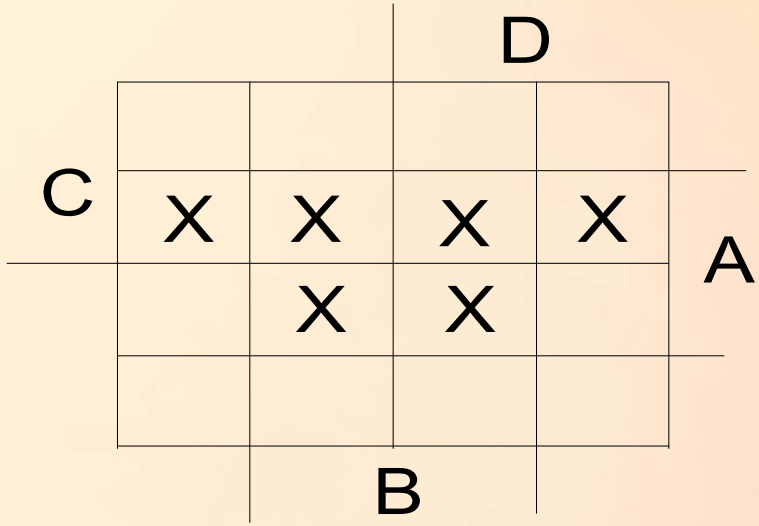
Design of BCD/7Seg. Convertor

$$a = C + A + \overline{B}\,\overline{D} + BD$$

$$b = A + CD + \overline{C}\,\overline{D} + B\overline{D}$$

$$c = B + CD + \overline{C}\,\overline{D} + \overline{A}\,\overline{C}$$

$$d = \sum m(0,2,3,5,6,8,9)$$



Design of BCD/7Seg. Convertor

$$a = C + A + \overline{B}\,\overline{D} + BD$$

$$b = A + CD + \overline{C}\,\overline{D} + B\overline{D}$$

$$c = B + CD + \overline{C}\,\overline{D} + \overline{A}\,\overline{C}$$

$$d = \sum m(0,2,3,5,6,8,9)$$

C \ AB \ D	00	01	11	10
00	1	1		1
01	X	X	X	X
11	1	X	X	1
10	1		1	

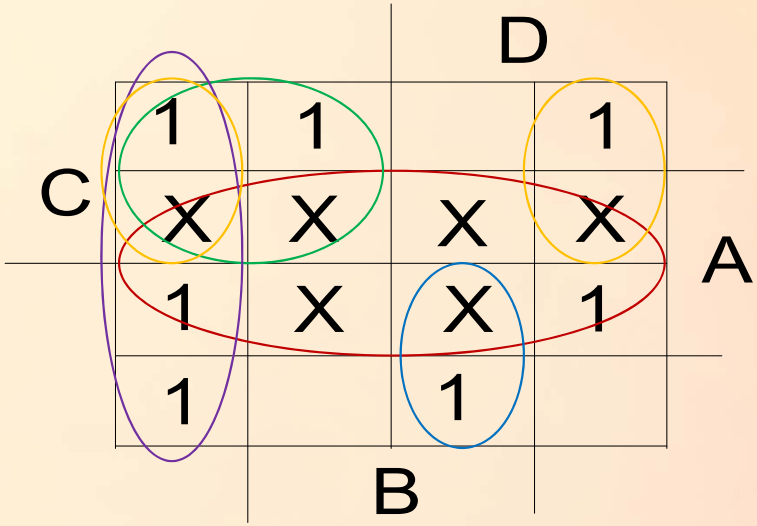
Design of BCD/7Seg. Convertor

$$a = C + A + \overline{B}\,\overline{D} + BD$$

$$b = A + CD + \overline{C}\,\overline{D} + \overline{B}D$$

$$c = B + CD + \overline{C}\,\overline{D} + \overline{A}C$$

$$d = A + C\overline{D} + C\overline{B} + \overline{B}\,\overline{D} + B\overline{C}D$$



Design of BCD/7Seg. Convertor

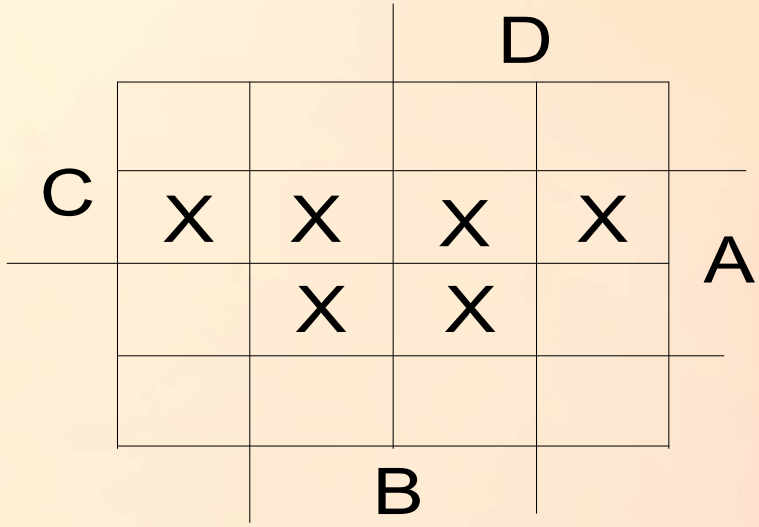
$$a = C + A + \overline{B}\,\overline{D} + BD$$

$$b = A + CD + \overline{C}\,\overline{D} + \overline{B}D$$

$$c = B + CD + \overline{C}\,\overline{D} + \overline{A}C$$

$$d = A + C\overline{D} + C\overline{B} + \overline{B}\,\overline{D} + B\overline{C}D$$

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



Design of BCD/7Seg. Convertor

$$a = C + A + \overline{B}\,\overline{D} + BD$$

$$b = A + CD + \overline{C}\,\overline{D} + \overline{B}D$$

$$c = B + CD + \overline{C}\,\overline{D} + \overline{A}\overline{C}$$

$$d = A + C\overline{D} + C\overline{B} + \overline{B}\,\overline{D} + B\overline{C}D$$

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

C \ AB \ D	00	01	11	10
00	1	1		
01	X	X	X	X
11	1	X	X	
10	1			

Design of BCD/7Seg. Convertor

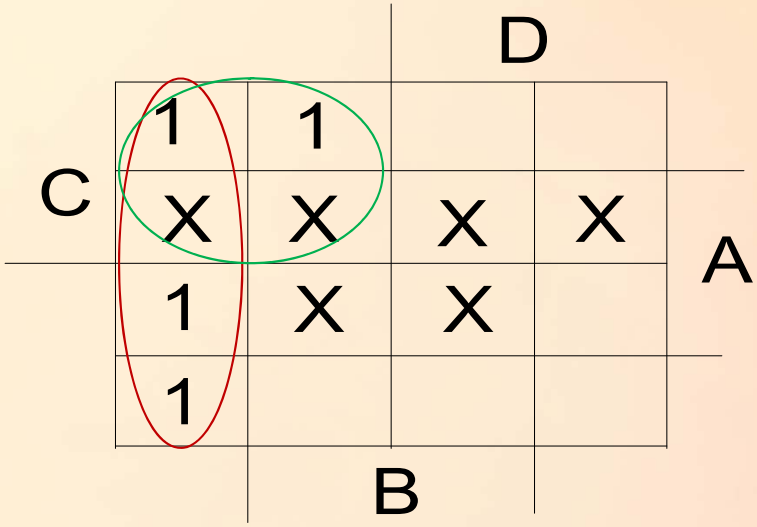
$$a = C + A + \overline{B}\,\overline{D} + BD$$

$$b = A + CD + \overline{C}\,\overline{D} + \overline{B}D$$

$$c = B + CD + \overline{C}\,\overline{D} + \overline{A}C$$

$$d = A + C\overline{D} + C\overline{B} + \overline{B}\,\overline{D} + B\overline{C}D$$

$$e = CD + \overline{B}\,\overline{D}$$



Design of BCD/7Seg. Convertor

$$a = C + A + \overline{B}\,\overline{D} + BD$$

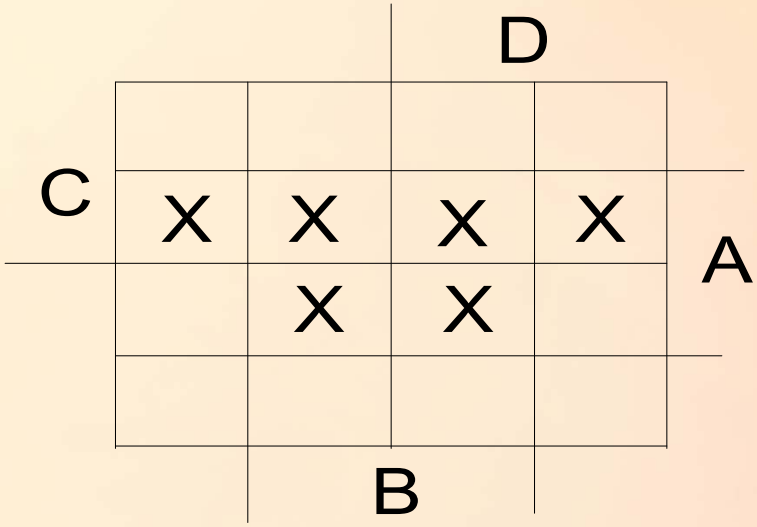
$$b = A + CD + \overline{C}\,\overline{D} + \overline{B}D$$

$$c = B + CD + \overline{C}\,\overline{D} + \overline{A}\overline{C}$$

$$d = A + C\overline{D} + C\overline{B} + \overline{B}\,\overline{D} + B\overline{C}D$$

$$e = CD + \overline{B}\,\overline{D}$$

$$f = \sum m(0,4,5,6,8,9)$$



Design of BCD/7Seg. Convertor

$$a = C + A + \overline{B}\,\overline{D} + BD$$

$$b = A + CD + \overline{C}\,\overline{D} + \overline{B}D$$

$$c = B + CD + \overline{C}\,\overline{D} + \overline{A}C$$

$$d = A + C\overline{D} + C\overline{B} + \overline{B}\,\overline{D} + B\overline{C}D$$

$$e = CD + \overline{B}\,\overline{D}$$

$$f = \sum m(0,4,5,6,8,9)$$

C \ D		1		
	X	X	X	X
	1	X	X	1
	1	1	1	

B (columns) — A (rows)

Design of BCD/7Seg. Convertor

$$a = C + A + \overline{B}\,\overline{D} + BD$$

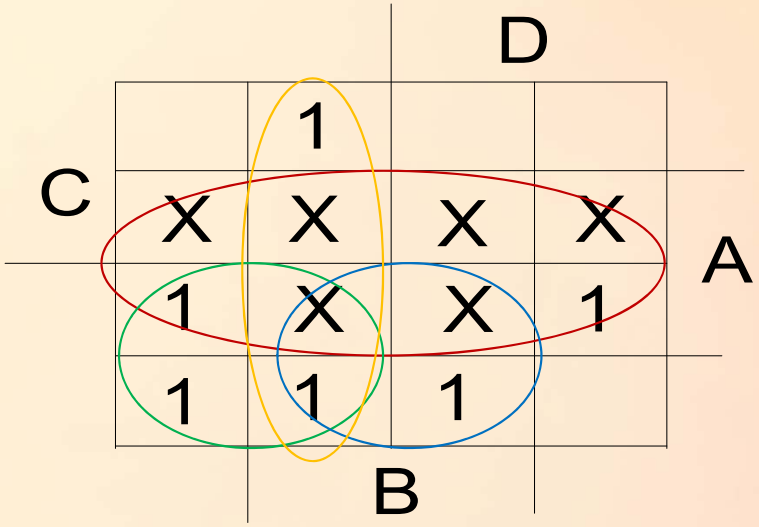
$$b = A + CD + \overline{C}\,\overline{D} + \overline{B}D$$

$$c = B + CD + \overline{C}\,\overline{D} + \overline{A}C$$

$$d = A + C\overline{D} + C\overline{B} + \overline{B}\,\overline{D} + B\overline{C}D$$

$$e = CD + \overline{B}\,\overline{D}$$

$$f = A + B\overline{C} + \overline{C}\,\overline{D} + B\overline{D}$$



Design of BCD/7Seg. Convertor

$$a = C + A + \overline{B}\,\overline{D} + BD$$

$$b = A + CD + \overline{C}\,\overline{D} + \overline{B}D$$

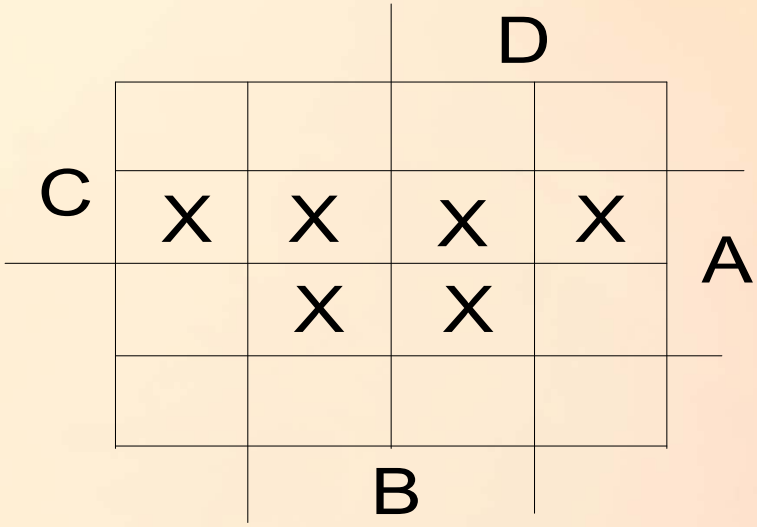
$$c = B + CD + \overline{C}\,\overline{D} + \overline{A}C$$

$$d = A + C\overline{D} + C\overline{B} + \overline{B}\,\overline{D} + B\overline{C}D$$

$$e = CD + \overline{B}\,\overline{D}$$

$$f = A + B\overline{C} + \overline{C}\,\overline{D} + B\overline{D}$$

$$g = \sum m(2,3,4,5,6,8)$$



Design of BCD/7Seg. Convertor

$$a = C + A + \overline{B}\,\overline{D} + BD$$

$$b = A + CD + \overline{C}\,\overline{D} + \overline{B}D$$

$$c = B + CD + \overline{C}\,\overline{D} + \overline{A}C$$

$$d = A + C\overline{D} + C\overline{B} + \overline{B}\,\overline{D} + B\overline{C}D$$

$$e = CD + \overline{B}\,\overline{D}$$

$$f = A + B\overline{C} + \overline{C}\,\overline{D} + B\overline{D}$$

$$g = \sum m(2,3,4,5,6,8)$$

C \ AB \ D	00	01	11	10
00	1	1		1
01	X	X	X	X
11	1	X	X	
10		1	1	

Design of BCD/7Seg. Convertor

$$a = C + A + \overline{B}\,\overline{D} + BD$$

$$b = A + CD + \overline{C}\,\overline{D} + \overline{B}D$$

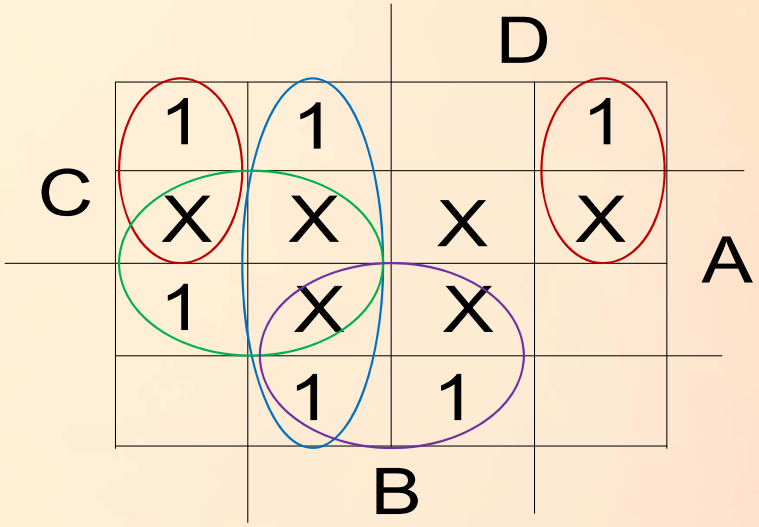
$$c = B + CD + \overline{C}\,\overline{D} + \overline{A}C$$

$$d = A + C\overline{D} + C\overline{B} + \overline{B}\,\overline{D} + B\overline{C}D$$

$$e = CD + \overline{B}\,\overline{D}$$

$$f = A + B\overline{C} + \overline{C}\,\overline{D} + B\overline{D}$$

$$g = C\overline{B} + B\overline{D} + A\overline{D} + B\overline{C}$$



Design of BCD/Aiken Convertor

	A	B	C	D	A'	B'	C'	D'
0	0	0	0	0	0	0	0	0
1	0	0	0	1	0	0	0	1
2	0	0	1	0	0	0	1	0
3	0	0	1	1	0	0	1	1
4	0	1	0	0	0	1	0	0
5	0	1	0	1	1	0	1	1
6	0	1	1	0	1	1	0	0
7	0	1	1	1	1	1	0	1

Design of BCD/Aiken Convertor

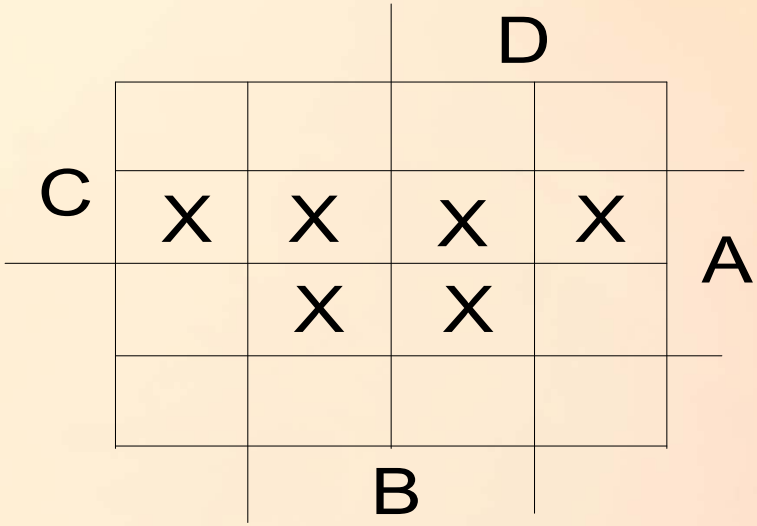
	A	B	C	D	A'	B'	C'	D'
0	0	0	0	0	0	0	0	0
1	0	0	0	1	0	0	0	1
2	0	0	1	0	0	0	1	0
3	0	0	1	1	0	0	1	1
4	0	1	0	0	0	1	0	0
5	0	1	0	1	1	0	1	1
6	0	1	1	0	1	1	0	0
7	0	1	1	1	1	1	0	1
8	1	0	0	0	1	1	1	0

Design of BCD/Aiken Convertor

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

Design of BCD/Aiken Convertor

$$A' = \sum m(5,6,7,8,9)$$



Design of BCD/Aiken Convertor

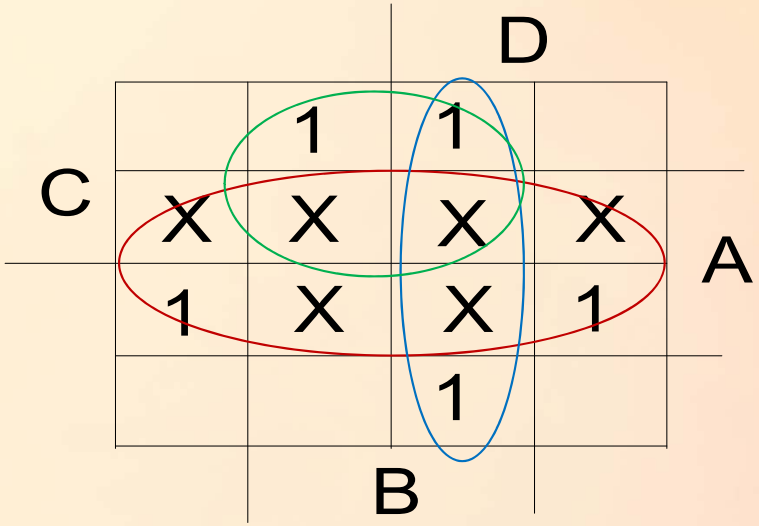
$$A' = \sum m(5,6,7,8,9)$$

C \ D				
		1	1	
	X	X	X	X
A	1	X	X	1
			1	

B

Design of BCD/Aiken Convertor

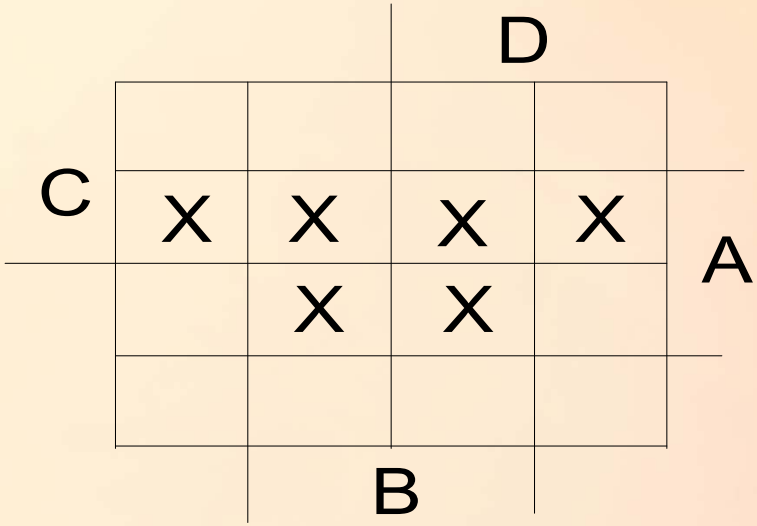
$$A' = A + CD + BD$$



Design of BCD/Aiken Convertor

$$A' = A + CD + BD$$

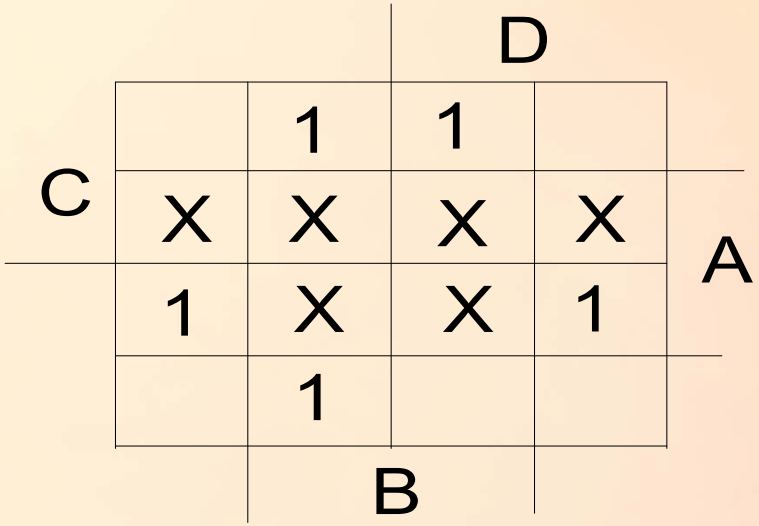
$$B' = \sum m(4,6,7,8,9)$$



Design of BCD/Aiken Convertor

$$A' = A + CD + BD$$

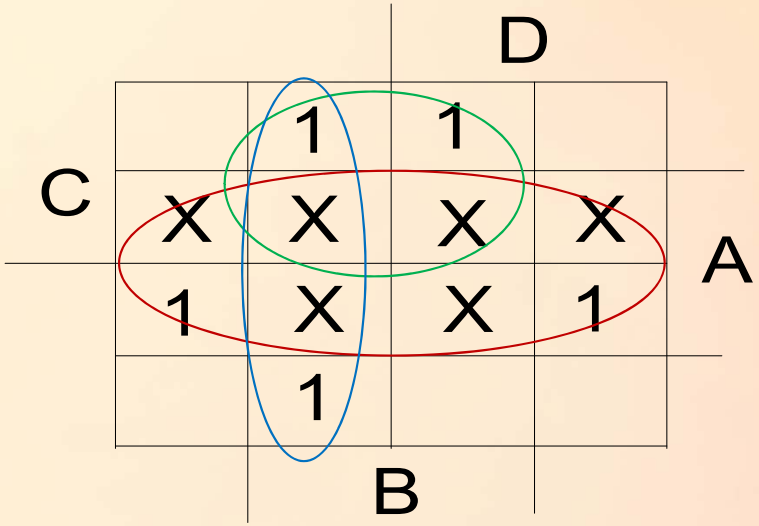
$$B' = \sum m(4,6,7,8,9)$$



Design of BCD/Aiken Convertor

$$A' = A + CD + BD$$

$$B' = A + CD + B\overline{D}$$

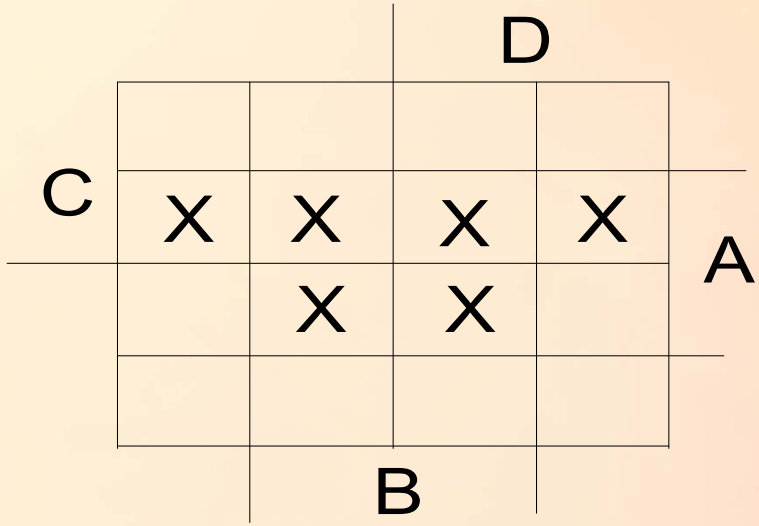


Design of BCD/Aiken Convertor

$$A' = A + CD + BD$$

$$B' = A + CD + B\overline{D}$$

$$C' = \sum m(2,3,5,8,9)$$



Design of BCD/Aiken Convertor

$$A' = A + CD + BD$$

$$B' = A + CD + B\overline{D}$$

$$C' = \sum m(2,3,5,8,9)$$

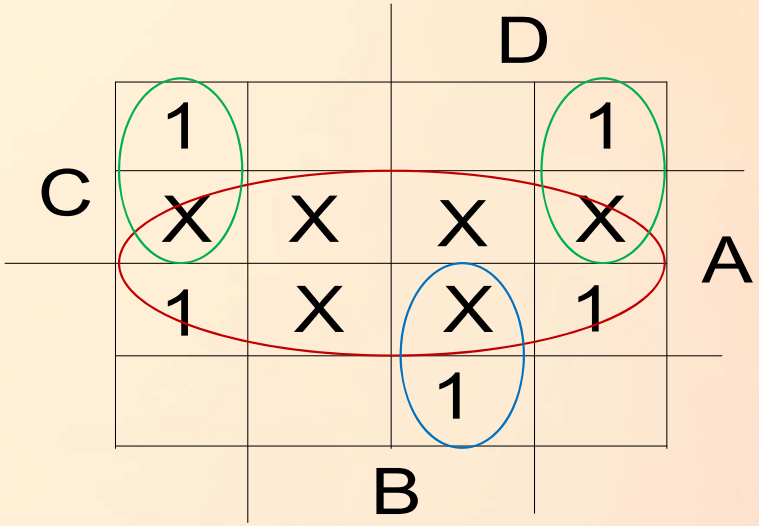
C \ AB \ D				
	1			1
	X	X	X	X
	1	X	X	1
			1	

Design of BCD/Aiken Convertor

$$A' = A + CD + BD$$

$$B' = A + CD + B\overline{D}$$

$$C' = A + \overline{B}C + B\overline{C}D$$



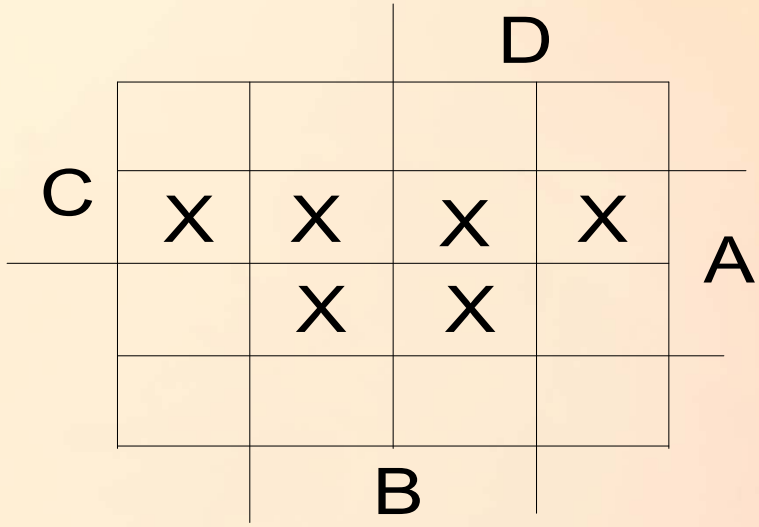
Design of BCD/Aiken Convertor

$$A' = A + CD + BD$$

$$B' = A + CD + B\overline{D}$$

$$C' = A + \overline{B}C + B\overline{C}D$$

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



Design of BCD/Aiken Convertor

$$A' = A + CD + BD$$

$$B' = A + CD + B\overline{D}$$

$$C' = A + \overline{B}C + B\overline{C}D$$

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

C \ AB	00	01	11	10
00			1	1
01	X	X	X	X
11		X	X	1
10			1	1

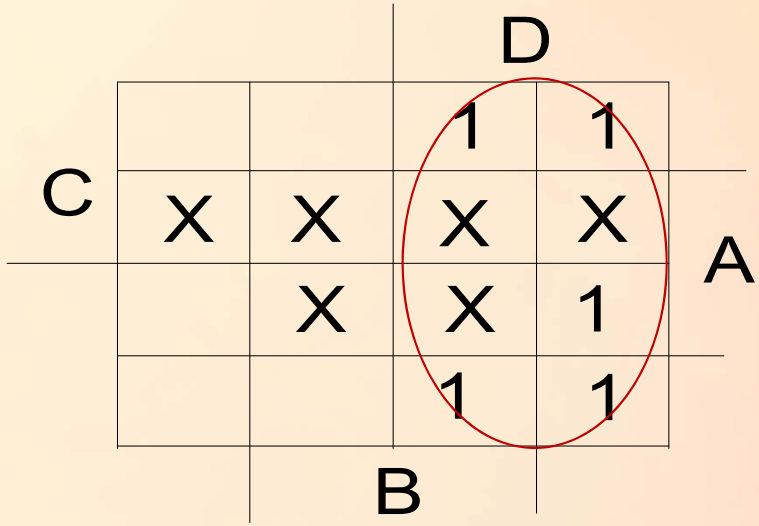
Design of BCD/Aiken Convertor

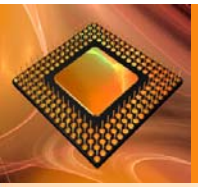
$$A' = A + CD + BD$$

$$B' = A + CD + B\overline{D}$$

$$C' = A + \overline{B}C + B\overline{C}D$$

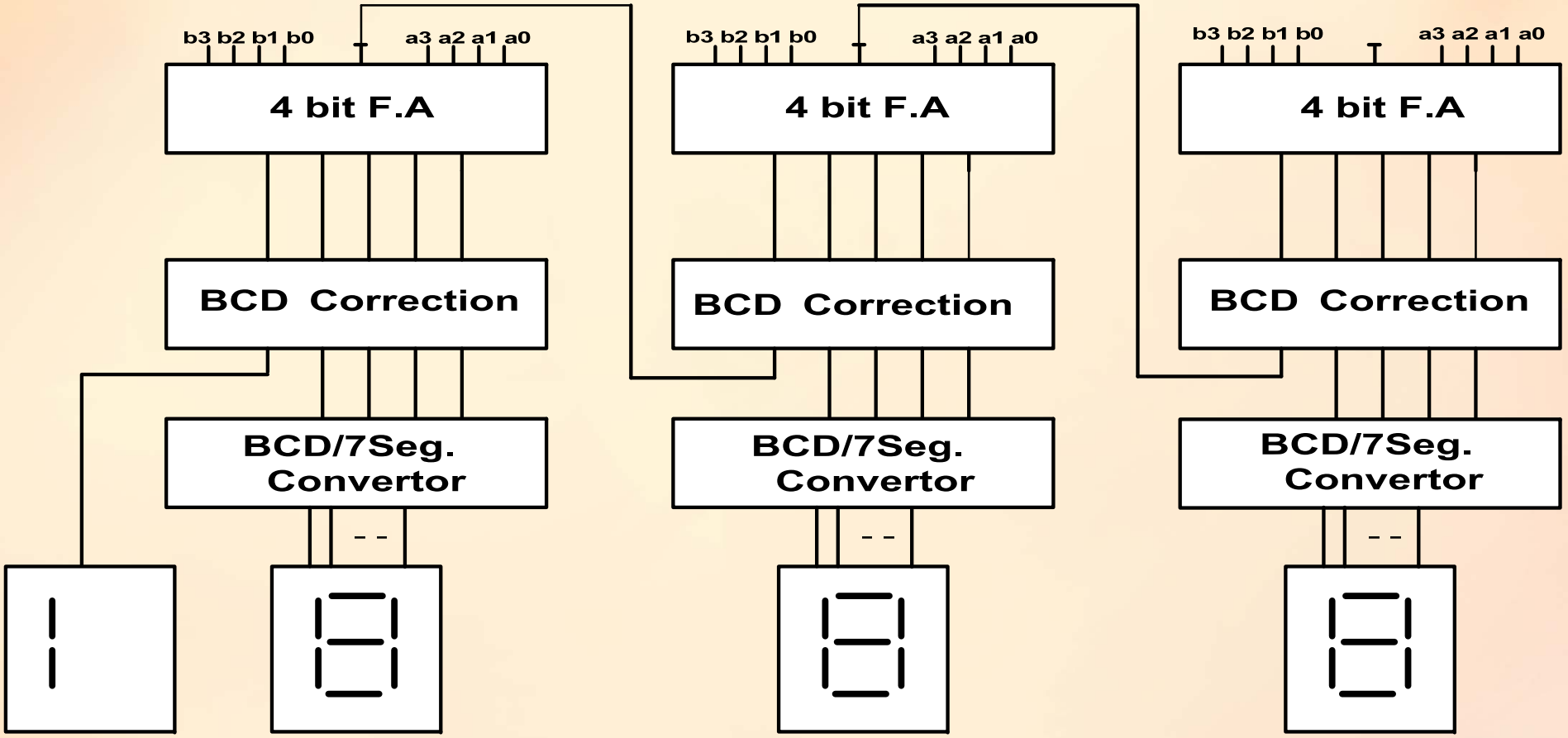
$$D' = D$$

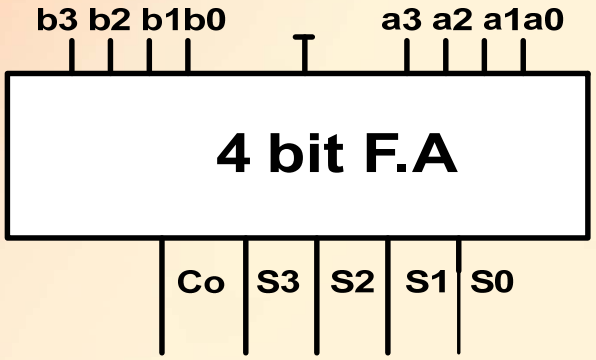




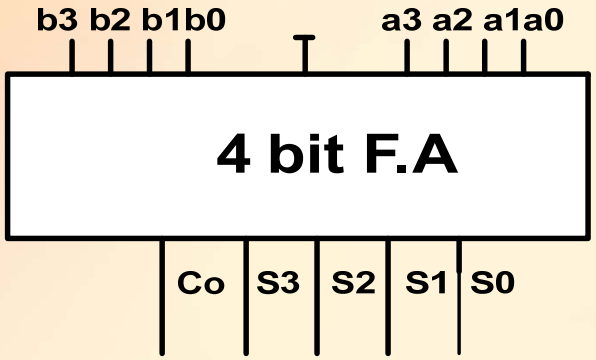
BCD CORRECTION

Add in BCD code

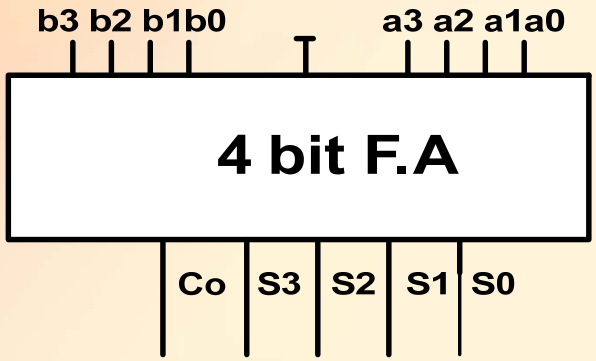




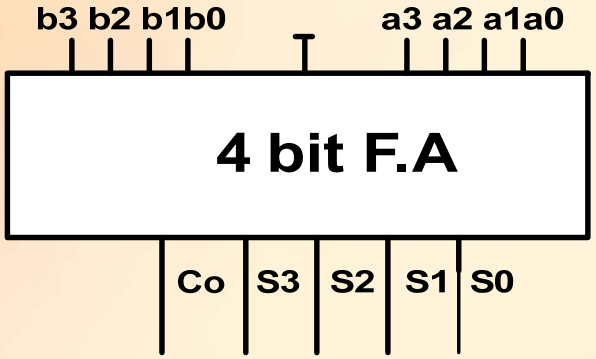
Co	S3	S2	S1	S0		Co'	S3'	S2'	S1'	S0'
0	0	0	0	0						
0	0	0	0	1						
0	0	0	1	0						
0	0	0	1	1						
0	0	1	0	0						
0	0	1	0	1						
0	0	1	1	0						
0	0	1	1	1						
0	1	0	0	0						
0	1	0	0	1						
0	1	0	1	0						
0	1	0	1	1						
0	1	1	0	0						
0	1	1	0	1						
0	1	1	1	0						
0	1	1	1	1						
1	0	0	0	0						
1	0	0	0	1						
1	0	0	1	0						
1	0	0	1	1						



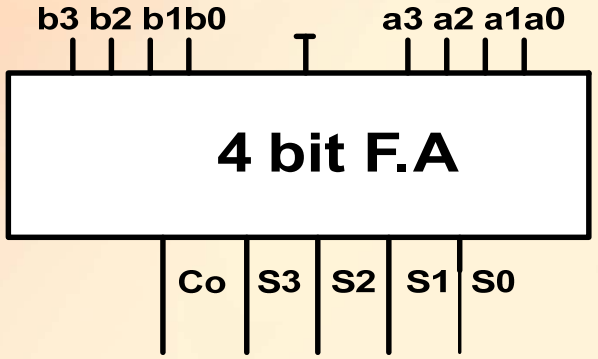
Co	S3	S2	S1	S0		Co'	S3'	S2'	S1'	S0'
0	0	0	0	0		0	0	0	0	0
0	0	0	0	1		0	0	0	0	1
0	0	0	1	0		0	0	0	1	0
0	0	0	1	1		0	0	0	1	1
0	0	1	0	0		0	0	1	0	0
0	0	1	0	1		0	0	1	0	1
0	0	1	1	0		0	0	1	1	0
0	0	1	1	1		0	0	1	1	1
0	1	0	0	0		0	1	0	0	0
0	1	0	0	1		0	1	0	0	1
0	1	0	1	0		1	0	0	0	0
0	1	0	1	1		1	0	0	0	1
0	1	1	0	0		1	0	0	1	0
0	1	1	0	1		1	0	0	1	1
0	1	1	1	0		1	0	1	0	0
0	1	1	1	1		1	0	1	0	1
1	0	0	0	0		1	0	1	1	0
1	0	0	0	1		1	0	1	1	1
1	0	0	1	0		1	1	0	0	0
1	0	0	1	1		1	1	0	0	1



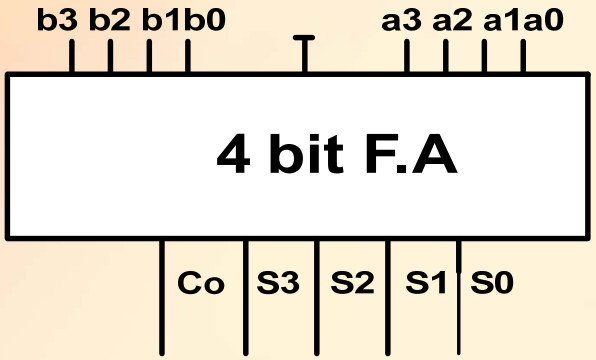
Co	S3	S2	S1	S0		Co'	S3'	S2'	S1'	S0'
0	0	0	0	0		0	0	0	0	0
0	0	0	0	1		0	0	0	0	1
0	0	0	1	0		0	0	0	1	0
0	0	0	1	1		0	0	0	1	1
0	0	1	0	0		0	0	1	0	0
0	0	1	0	1		0	0	1	0	1
0	0	1	1	0		0	0	1	1	0
0	0	1	1	1		0	0	1	1	1
0	1	0	0	0		0	1	0	0	0
0	1	0	0	1		0	1	0	0	1
0	1	0	1	0		1	0	0	0	0
0	1	0	1	1		1	0	0	0	1
0	1	1	0	0		1	0	0	1	0
0	1	1	0	1		1	0	0	1	1
0	1	1	1	0		1	0	1	0	0
0	1	1	1	1		1	0	1	0	1
1	0	0	0	0		1	0	1	1	0
1	0	0	0	1		1	0	1	1	1
1	0	0	1	0		1	1	0	0	0
1	0	0	1	1		1	1	0	0	1



Co	S3	S2	S1	S0		Co'	S3'	S2'	S1'	S0'
0	0	0	0	0		0	0	0	0	0
0	0	0	0	1		0	0	0	0	1
0	0	0	1	0		0	0	0	1	0
0	0	0	1	1		0	0	0	1	1
0	0	1	0	0		0	0	1	0	0
0	0	1	0	1		0	0	1	0	1
0	0	1	1	0		0	0	1	1	0
0	0	1	1	1		0	0	1	1	1
0	1	0	0	0		0	1	0	0	0
0	1	0	0	1		0	1	0	0	1
0	1	0	1	0		1	0	0	0	0
0	1	0	1	1		1	0	0	0	1
0	1	1	0	0		1	0	0	1	0
0	1	1	0	1		1	0	0	1	1
0	1	1	1	0		1	0	1	0	0
0	1	1	1	1		1	0	1	0	1
1	0	0	0	0		1	0	1	1	0
1	0	0	0	1		1	0	1	1	1
1	0	0	1	0		1	1	0	0	0
1	0	0	1	1		1	1	0	0	1



Co	S3	S2	S1	S0		Co'	S3'	S2'	S1'	S0'
0	0	0	0	0		0	0	0	0	0
0	0	0	0	1		0	0	0	0	1
0	0	0	1	0		0	0	0	1	0
0	0	0	1	1		0	0	0	1	1
0	0	1	0	0		0	0	1	0	0
0	0	1	0	1		0	0	1	0	1
0	0	1	1	0		0	0	1	1	0
0	0	1	1	1		0	0	1	1	1
0	1	0	0	0		0	1	0	0	0
0	1	0	0	1		0	1	0	0	1
0	1	0	1	0		1	0	0	0	0
0	1	0	1	1		1	0	0	0	1
0	1	1	0	0		1	0	0	1	0
0	1	1	0	1		1	0	0	1	1
0	1	1	1	0		1	0	1	0	0
0	1	1	1	1		1	0	1	0	1
1	0	0	0	0		1	0	1	1	0
1	0	0	0	1		1	0	1	1	1
1	0	0	1	0		1	1	0	0	0
1	0	0	1	1		1	1	0	0	1

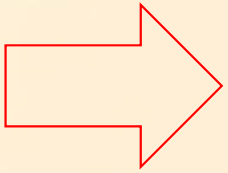


+6

Co	S3	S2	S1	S0		Co'	S3'	S2'	S1'	S0'
0	0	0	0	0		0	0	0	0	0
0	0	0	0	1		0	0	0	0	1
0	0	0	1	0		0	0	0	1	0
0	0	0	1	1		0	0	0	1	1
0	0	1	0	0		0	0	1	0	0
0	0	1	0	1		0	0	1	0	1
0	0	1	1	0		0	0	1	1	0
0	0	1	1	1		0	0	1	1	1
0	1	0	0	0		0	1	0	0	0
0	1	0	0	1		0	1	0	0	1
0	1	0	1	0		1	0	0	0	0
0	1	0	1	1		1	0	0	0	1
0	1	1	0	0		1	0	0	1	0
0	1	1	0	1		1	0	0	1	1
0	1	1	1	0		1	0	1	0	0
0	1	1	1	1		1	0	1	0	1
1	0	0	0	0		1	0	1	1	0
1	0	0	0	1		1	0	1	1	1
1	0	0	1	0		1	1	0	0	0
1	0	0	1	1		1	1	0	0	1

Add in BCD code

C0	S3	S2	S1	S0
0	0	0	0	0
0	0	0	0	1
0	0	0	1	0
0	0	0	1	1
0	0	1	0	0
0	0	1	0	1
0	0	1	1	0
0	0	1	1	1
0	1	0	0	0
0	1	0	0	1



Without correction

Add in BCD code

C0	S3	S2	S1	S0
0	1	0	1	0
0	1	0	1	1
0	1	1	0	0
0	1	1	0	1
0	1	1	1	0
0	1	1	1	1
1	0	0	0	0
1	0	0	0	1
1	0	0	1	0
1	0	0	1	1

correction area

Add in BCD code

F=S3.S1

correction area

C_0	S_3	S_2	S_1	S_0
0	1	0	1	0
0	1	0	1	1
0	1	1	0	0
0	1	1	0	1
0	1	1	1	0
0	1	1	1	1
1	0	0	0	0
1	0	0	0	1
1	0	0	1	0
1	0	0	1	1

Add in BCD code

F=S3.S1

correction area

C_0	S_3	S_2	S_1	S_0
0	1	0	1	0
0	1	0	1	1
0	1	1	0	0
0	1	1	0	1
0	1	1	1	0
0	1	1	1	1
1	0	0	0	0
1	0	0	0	1
1	0	0	1	0
1	0	0	1	1

+ 6

C_0	S_3	S_2	S_1	S_0
1	0	0	0	0
1	0	0	0	1

Add in BCD code

F=S3.S1+S3.S2

correction area

C_0	S_3	S_2	S_1	S_0
0	1	0	1	0
0	1	0	1	1
0	1	1	0	0
0	1	1	0	1
0	1	1	1	0
0	1	1	1	1
1	0	0	0	0
1	0	0	0	1
1	0	0	1	0
1	0	0	1	1

+ 6

C_0	S_3	S_2	S_1	S_0
1	0	0	0	0
1	0	0	0	1
1	0	0	1	0
1	0	0	1	1
1	0	1	0	0
1	0	1	0	1

Add in BCD code

F=S3.S1+S3.S2+Co

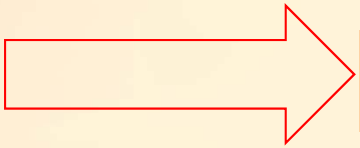
correction area

C_0	S_3	S_2	S_1	S_0
0	1	0	1	0
0	1	0	1	1
0	1	1	0	0
0	1	1	0	1
0	1	1	1	0
0	1	1	1	1
1	0	0	0	0
1	0	0	0	1
1	0	0	1	0
1	0	0	1	1

+ 6

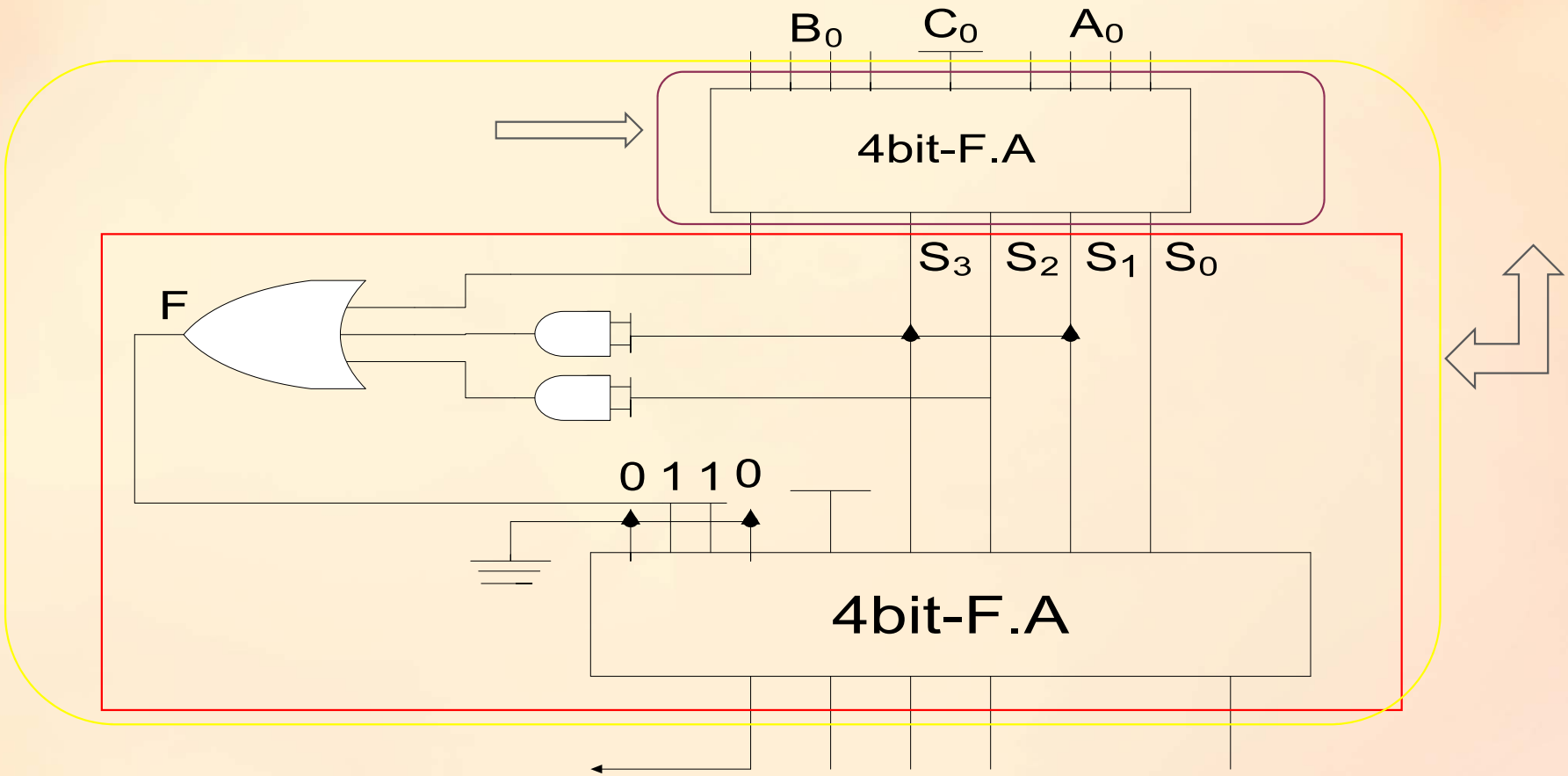
C_0	S_3	S_2	S_1	S_0
1	0	0	0	0
1	0	0	0	1
1	0	0	1	0
1	0	0	1	1
1	0	1	0	0
1	0	1	0	1
1	0	1	1	0
1	0	1	1	1
1	1	0	0	0
1	1	0	0	1

Add in BCD code



F=S3.S1+S3.S2+Co

Add in BCD code



Thank You