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Combinatorial Circuit Design

- Some useful components can be designed using the gates and the components described so far during the course
- This presentation describes the design of a binary coded decimal (BCD) to 7 segment decoder, which is used in digital displays
- This design will use only combinatorial logic gates, making use of the minimization logic techniques we have described

Design Requirements
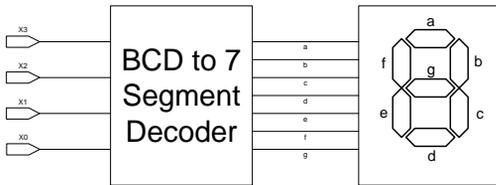
Design the logic circuitry that will drive a seven segment LED display and will be able to represent numbers from 0 to 9

Possible numbers and their representation on 7 segment display
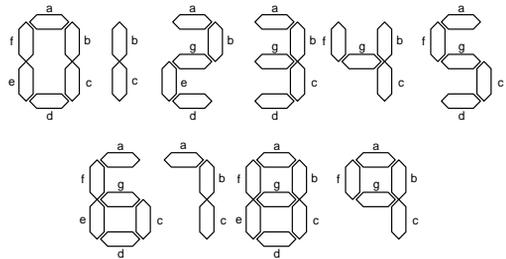
Truth Table

X3	X2	X1	X0	a	b	c	d	e	f	g
0	0	0	0	1	1	1	1	1	1	0
0	0	0	1	0	1	1	0	0	0	0
0	0	1	0	1	1	0	1	1	0	1
0	0	1	1	1	1	1	1	0	0	1
0	1	0	0	0	1	1	0	0	1	1
0	1	0	1	1	0	1	1	0	1	1
0	1	1	0	1	0	1	1	1	1	1
0	1	1	1	1	1	1	0	0	0	0
1	0	0	0	1	1	1	1	1	1	1
1	0	0	1	1	1	1	0	0	1	1
1	0	1	0	x	x	x	x	x	x	x
1	0	1	1	x	x	x	x	x	x	x
1	1	0	0	x	x	x	x	x	x	x
1	1	0	1	x	x	x	x	x	x	x
1	1	1	0	x	x	x	x	x	x	x
1	1	1	1	x	x	x	x	x	x	x
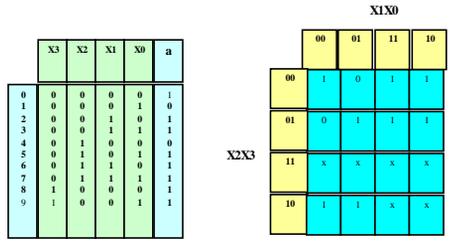
Signal a implementation

a = f(X3, X2, X1, X0) =

X3

+ X1

+ X2X0

+ X2'X1'X0'
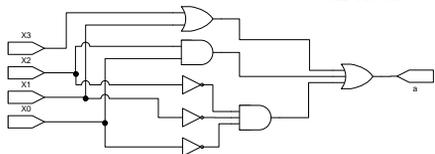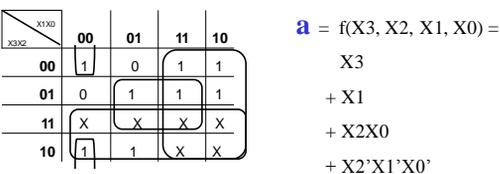
Signal b implementation

b = f(X3, X2, X1, X0) =

X1'X0'

+ X1X0

+ X2'
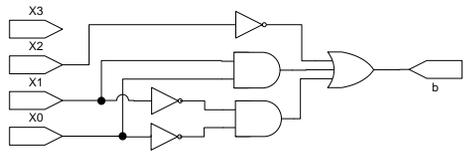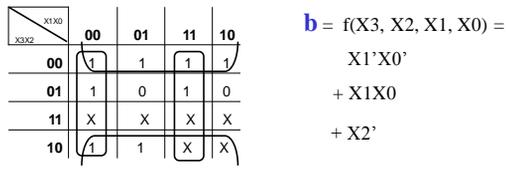
Signal c implementation

X3X2 \ X1X0	00	01	11	10
00	1	1	1	0
01	1	1	1	1
11	X	X	X	X
10	1	1	X	X

c = f(X3, X2, X1, X0) =

X1'+

+ X0

+ X2
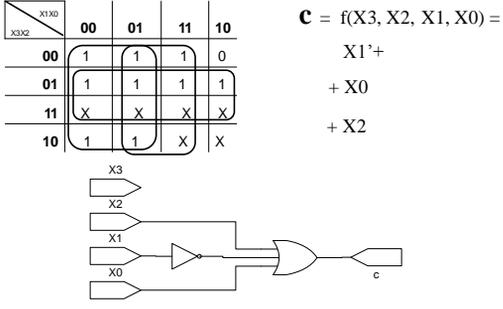
Signal d implementation

X3X2 \ X1X0	00	01	11	10
00	1	0	1	1
01	0	1	0	1
11	X	X	X	X
10	1	0	X	X

d = f(X3, X2, X1, X0) =

X3X1'X0'+
+ X2'X1'X0'
+ X3'X2'X1
+ X2X1'X0
+ X1X0'
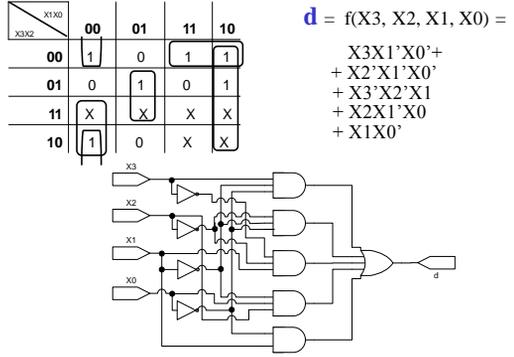
Signal e implementation

X3X2 \ X1X0	00	01	11	10
00	1	0	0	1
01	0	0	0	1
11	X	X	X	X
10	1	0	X	X

e = f(X3, X2, X1, X0) =

X1X0'

+ X2'X1'X0'
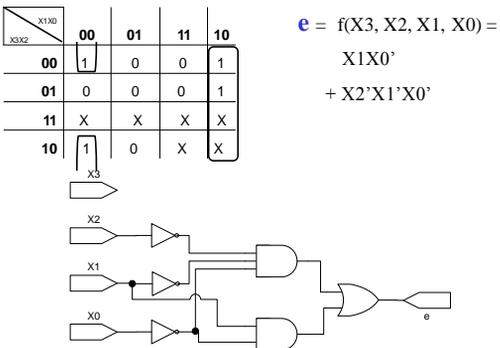
Signal f implementation

X3X2 \ X1X0	00	01	11	10
00	1	0	0	0
01	1	1	0	1
11	X	X	X	X
10	1	1	X	X

f = f(X3, X2, X1, X0) =

X3

+ X2X0'

+ X1'X0'

+ X2X1'
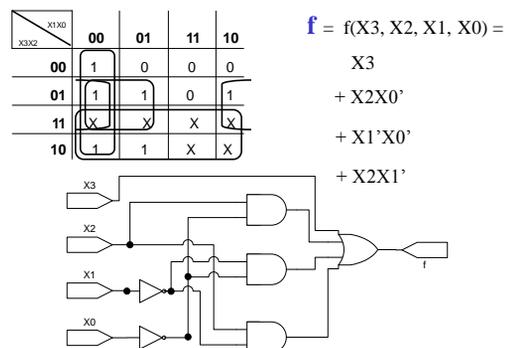
Signal g implementation

X3X2 \ X1X0	00	01	11	10
00	0	0	1	1
01	1	1	0	1
11	X	X	X	X
10	1	1	X	X

$g = f(X3, X2, X1, X0) =$

$X3$

$+ X1'X0'$

$+ X2X1'$

$+ X2'X1$
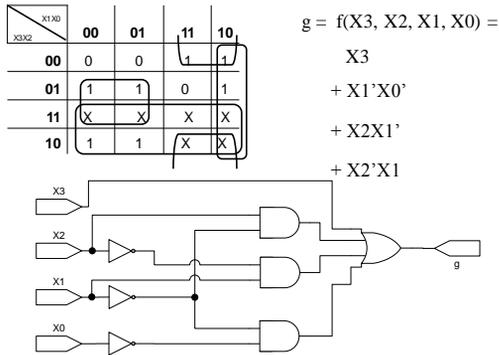
7 segment display
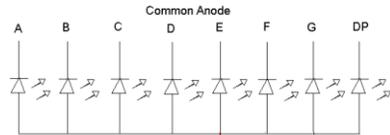
- All the **anode segments** are connected together
- Power must be applied externally to the **anode** connection that is common to all the segments
- By **applying the ground** to a particular segment (i.e. a,b,g etc..), the appropriate segment will light up

7 segment common anode
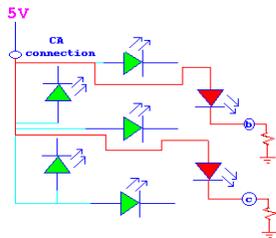
- **A resistor** should be added in order to limit the current through LED
- The current to light the active LED is sink by the logic component, which is preferable

7 segment Common Cathode
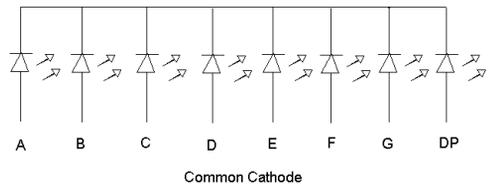
Common Cathode

- All the **cathode of the LED** are connected together
- The **common connection must be grounded** and **power** must be applied to **appropriate segment** in order to illuminate that segment
- The current to light the active LED is generated by the logic component, which generates the logic 1

7447 TTL IC
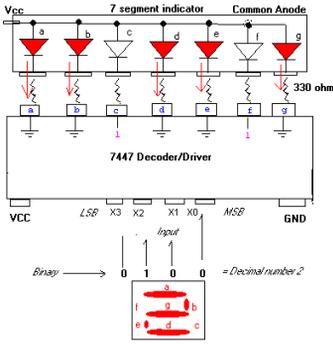
- Real world example of BCD to 7 segment decoder
- Outputs of the decoder are active low and a common anode 7 segment display is used