DECODER CIRCUIT

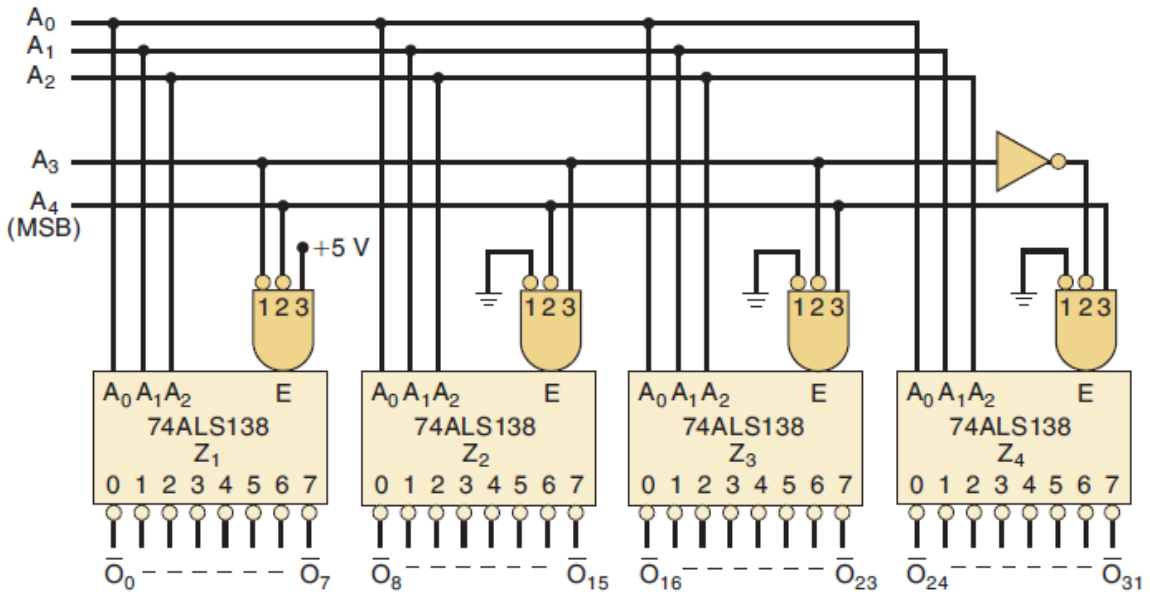
EXAMPLE 9-2

Figure 9-4(a) shows how four 74ALS138s and an INVERTER can be arranged to function as a 1-of-32 decoder. The decoders are labeled Z_1 to Z_4 for easy reference, and the eight outputs from each one are combined into 32 outputs. Z_1's outputs are $\overline{O}_0$ to $\overline{O}_7$; Z_2's outputs $\overline{O}_0$ to $\overline{O}_7$ are renamed $\overline{O}_8$ to $\overline{O}_{15}$, respectively; Z_3's outputs are renamed $\overline{O}_{16}$ to $\overline{O}_{23}$; and Z_4's are renamed $\overline{O}_{24}$ to $\overline{O}_{31}$. A five-bit input code $A_4A_3A_2A_1A_0$ will activate only one of these 32 outputs for each of the 32 possible input codes.

(a) Which output will be activated for $A_4A_3A_2A_1A_0 = 01101$?

(b) What range of input codes will activate the Z_4 chip?

(c) Create a megafunction circuit in Quartus that will implement a 1-of-32 decoder with active-HIGH outputs.

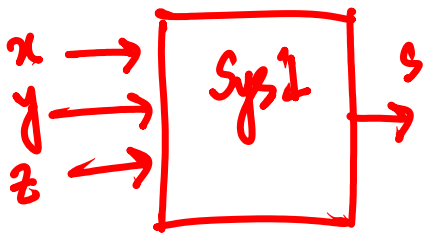


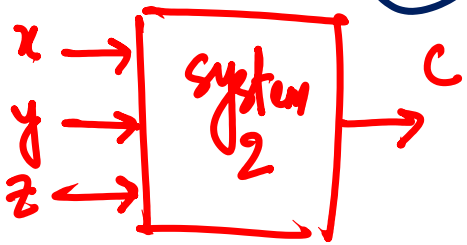
Ref (1): pp 663

DECODER CIRCUIT

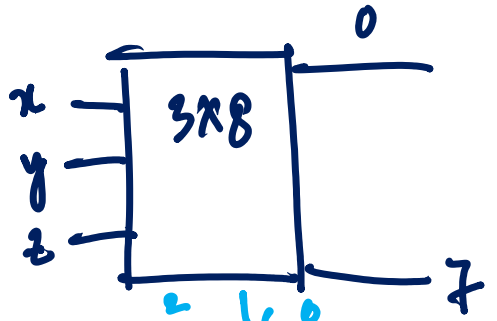
- Combinational logic implementation:

$$S(x, y, z) = \Sigma(1, 2, 4, 7) = m_1 + m_2 + m_4 + m_7$$
$$C(x, y, z) = \Sigma(3, 5, 6, 7) = m_3 + m_5 + m_6 + m_7$$



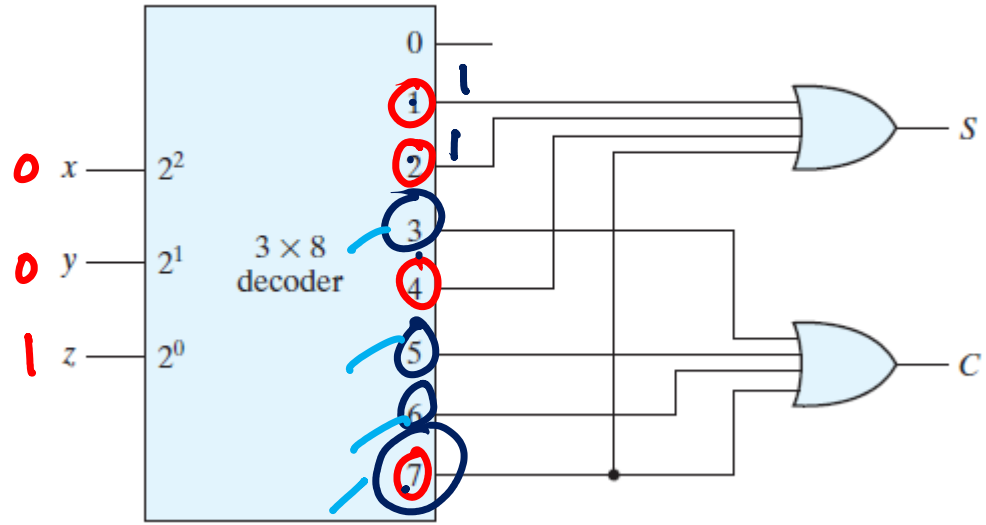


x	y	z	S	C
0	0	0	0	0
0	0	1	1	0
0	1	0	1	0
0	1	1	0	1
1	0	0	1	0
1	0	1	0	1
1	1	0	0	1
1	1	1	1	1



2^2	2^1	2^0
0	0	1

$\rightarrow 0 \times 2^2 + 0 \times 2^1 + 1 \times 2^0 = (1)_{10}$

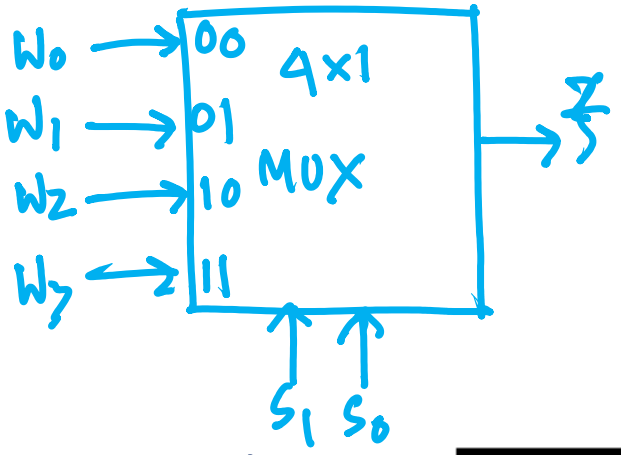


Ref (2): pp 195

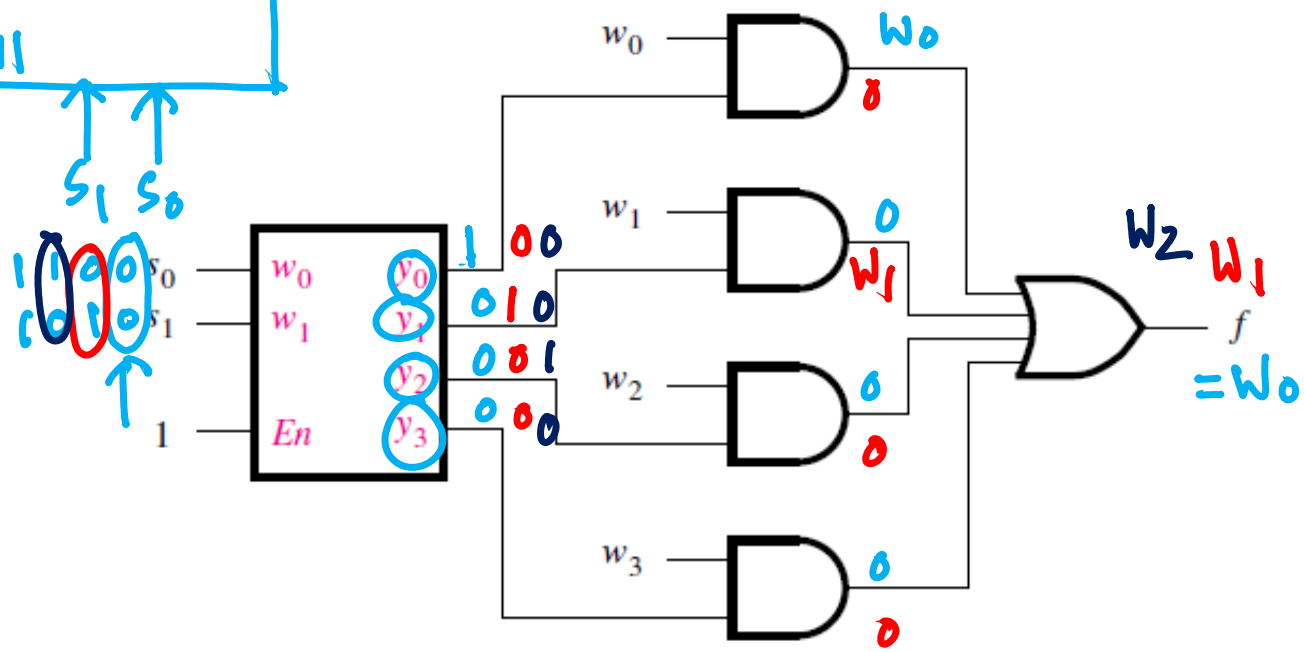
DECODER CIRCUIT

- Multiplexer circuit using decoder:

S_1	S_0	f
0	0	W_0
0	1	W_1
1	0	W_2
1	1	W_3



$$f = \bar{S_1}\bar{S_0}W_0 + \bar{S_1}S_0W_1 + S_1\bar{S_0}W_2 + S_1S_0W_3$$



DECODER CIRCUIT

$+V_{CC} = 5V \rightarrow 1$

$\perp = 0V \rightarrow 0$

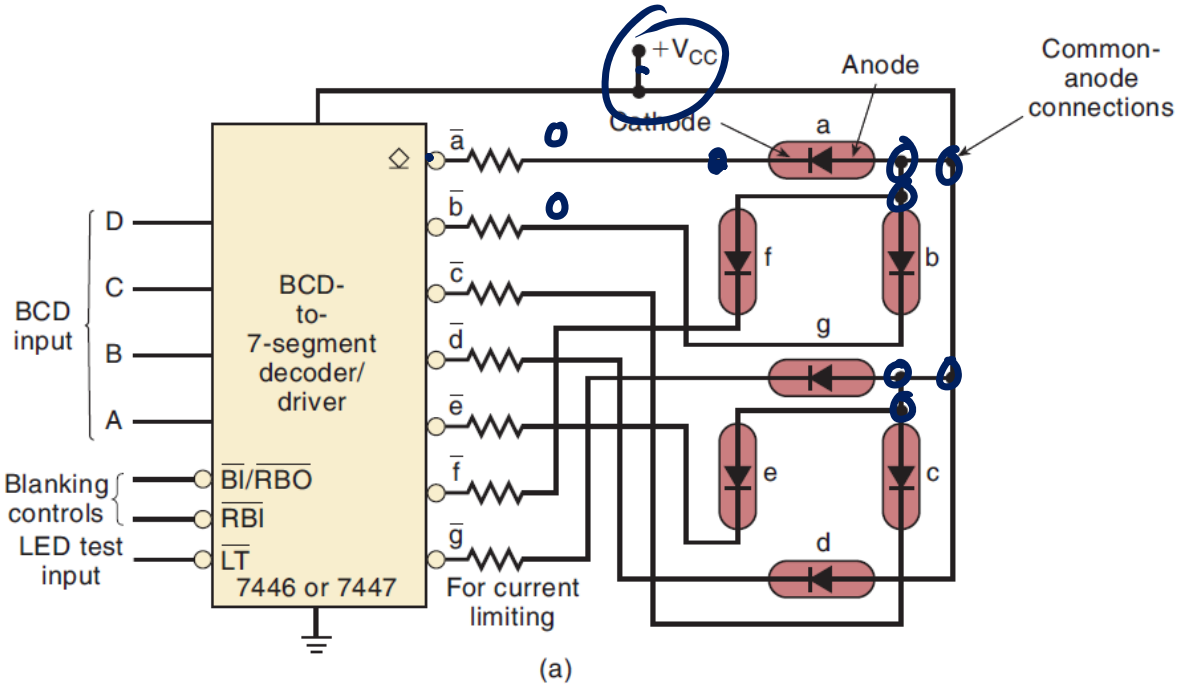
LED → Light emitting diode.

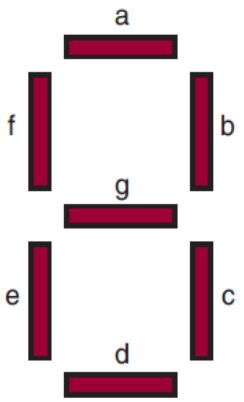
$V_A > V_K$

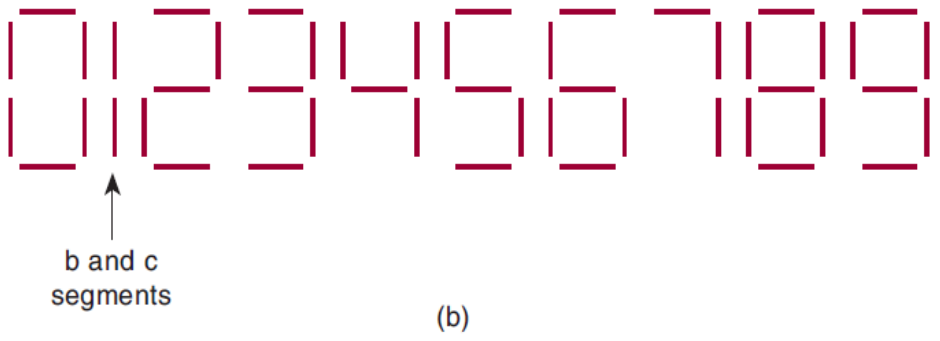
$V_A = +V_{CC} = 1$

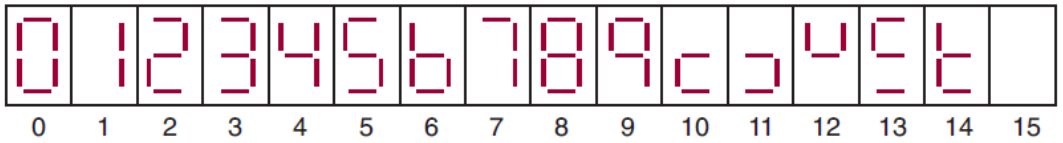
$V_K = \perp = 0$

- BCD to 7 segment decoder (common anode connection):





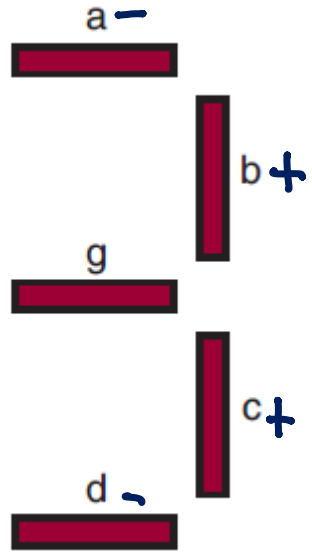


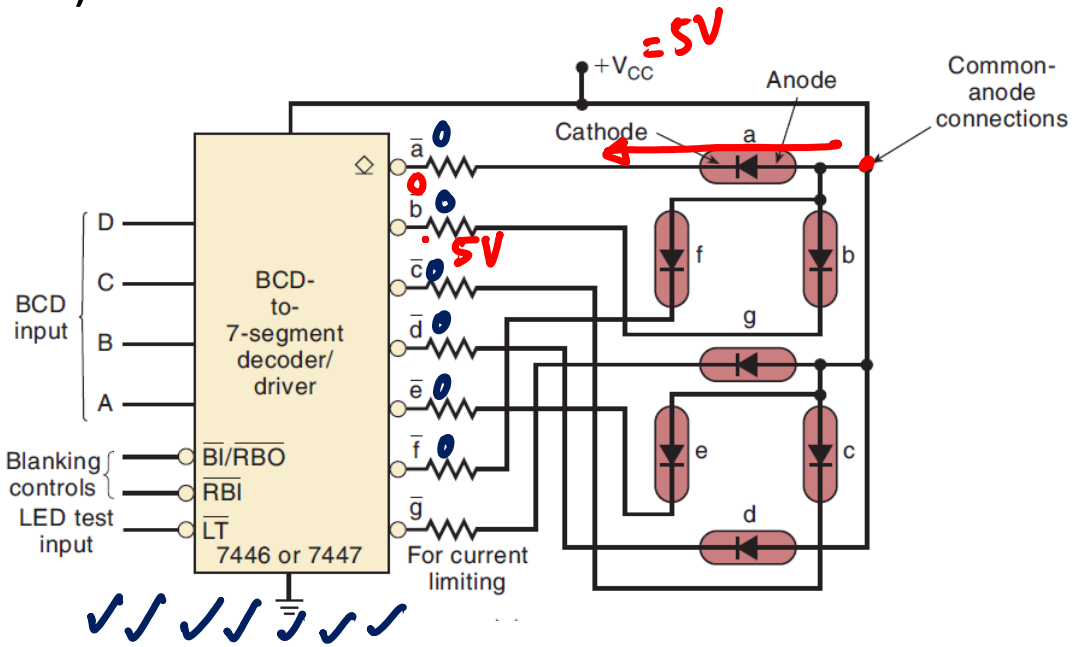


DECODER CIRCUIT

- BCD to 7 segment decoder (common anode connection):

Decimal	a	b	c	d	e	f	g
0	0	0	0	0	0	0	1
1	1	0	0	1	1	1	1
2	0	0	1	0	0	1	0
3	0	0	0	0	1	1	0
4	1	0	0	1	1	0	0
5	0	1	0	0	1	0	0
6	1	1	0	0	0	0	0
7	0	0	0	0	1	1	1
8	0	0	0	0	0	0	0
9	0	0	0	0	1	0	0





Decimal	A	B	C	D	a	b	c	d	e	f	g
10	1	0	1	0	X	X	X	X	X	X	X
11	1	0	1	1	X	X	X	X	X	X	X
12	1	1	0	0	X	X	X	X	X	X	X
13	1	1	0	1	X	X	X	X	X	X	X
14	1	1	1	0	X	X	X	X	X	X	X
15	1	1	1	1	X	X	X	X	X	X	X

$$a = \prod M\,(0, 2, 3, 5, 7, 8, 9)\; d\,(10, 11, 12, 13, 14, 15)$$

$$b = \prod M\,(0, 1, 2, 3, 4, 7, 8, 9)\; \prod d\,(10, 11, 12, 13, 14, 15)$$

$$c = \prod M\,(0, 1, 3, 4, 5, 6, 7, 8, 9)\; \prod d\,(10, 11, 12, 13, 14, 15)$$

$$d = \prod M\,(0, 2, 3, 5, 6, 8)\; \prod d\,(10, 11, 12, 13, 14, 15)$$

$$e = \prod M\,(0, 2, 6, 8, 9)\; \prod d\,(10, 11, 12, 13, 14, 15)$$

$$f = \prod M\,(0, 4, 5, 6, 8, 9)\; \prod d\,(10, 11, 12, 13, 14, 15)$$

$$g = \prod M\,(2, 3, 4, 5, 6, 8, 9)\; \prod d\,(10, 11, 12, 13, 14, 15)$$

DECODER CIRCUIT

- BCD to 7 segment decoder (common anode connection):

$a = \prod M\,(0, 2, 3, 5, 7, 8, 9)\; d\,(10, 11, 12, 13, 14, 15)$

$b = \prod M\,(0, 1, 2, 3, 4, 7, 8, 9)\; \prod d\,(10, 11, 12, 13, 14, 15)$

$c = \prod M\,(0, 1, 3, 4, 5, 6, 7, 8, 9)\; \prod d\,(10, 11, 12, 13, 14, 15)$

$d = \prod M\,(0, 2, 3, 5, 6, 8)\; \prod d\,(10, 11, 12, 13, 14, 15)$

$e = \prod M\,(0, 2, 6, 8, 9)\; \prod d\,(10, 11, 12, 13, 14, 15)$

$f = \prod M\,(0, 4, 5, 6, 8, 9)\; \prod d\,(10, 11, 12, 13, 14, 15)$

$g = \prod M\,(2, 3, 4, 5, 6, 8, 9)\; \prod d\,(10, 11, 12, 13, 14, 15)$

$$a = A\,(B + D)\,(B + C)(B + D)$$

$$b = B\,(\overline{C} + \overline{D})\,(C + D)$$

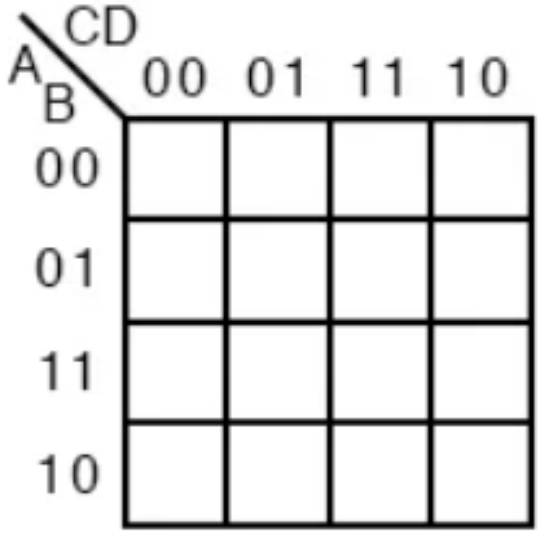
$$c = \overline{B}C\overline{D}$$

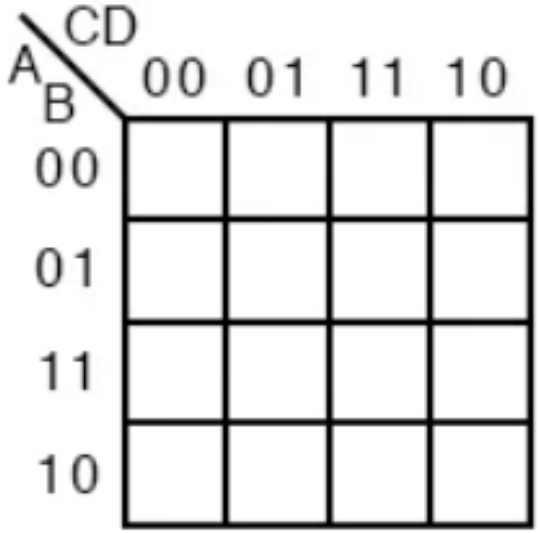
$$d = (\overline{C} + D)\,(B + \overline{C})(\overline{B} + C + \overline{D})\,(B + D)$$

$$e = (\overline{C} + D)\,(B + D)$$

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

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





DECODER CIRCUIT

- BCD to 7 segment decoder (common anode connection):

$a = \prod M\,(0, 2, 3, 5, 7, 8, 9)\; d\,(10, 11, 12, 13, 14, 15)$

$b = \prod M\,(0, 1, 2, 3, 4, 7, 8, 9)\; \prod d\,(10, 11, 12, 13, 14, 15)$

$c = \prod M\,(0, 1, 3, 4, 5, 6, 7, 8, 9)\; \prod d\,(10, 11, 12, 13, 14, 15)$

$d = \prod M\,(0, 2, 3, 5, 6, 8)\; \prod d\,(10, 11, 12, 13, 14, 15)$

$e = \prod M\,(0, 2, 6, 8, 9)\; \prod d\,(10, 11, 12, 13, 14, 15)$

$f = \prod M\,(0, 4, 5, 6, 8, 9)\; \prod d\,(10, 11, 12, 13, 14, 15)$

$g = \prod M\,(2, 3, 4, 5, 6, 8, 9)\; \prod d\,(10, 11, 12, 13, 14, 15)$

$$a = A\,(B + D)\,(B + C)(B + D)$$

$$b = B\,(\overline{C} + \overline{D})\,(C + D)$$

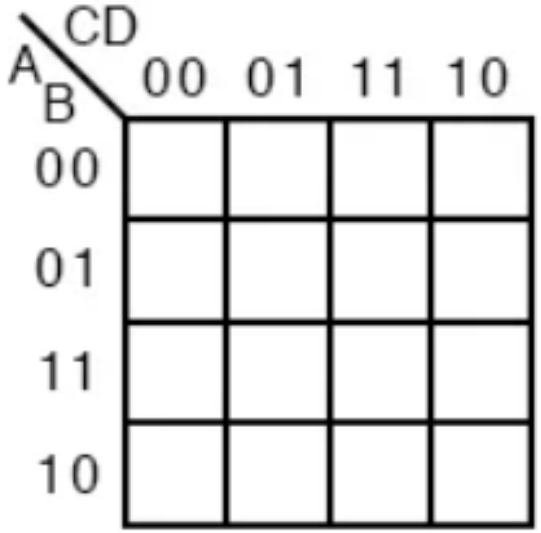
$$c = \overline{B}C\overline{D}$$

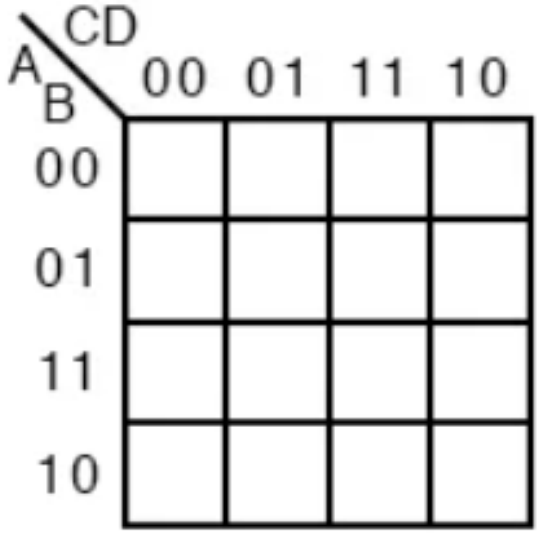
$$d = (\overline{C} + D)\,(B + \overline{C})(\overline{B} + C + \overline{D})\,(B + D)$$

$$e = (\overline{C} + D)\,(B + D)$$

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

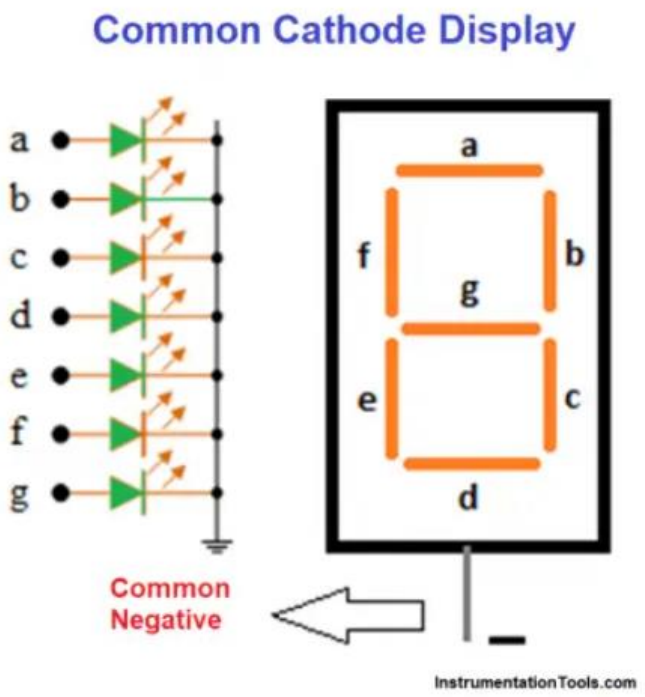
$$g = \overline{A}\,(\overline{B} + C)\,(\overline{C} + D)\,(B + \overline{C})$$

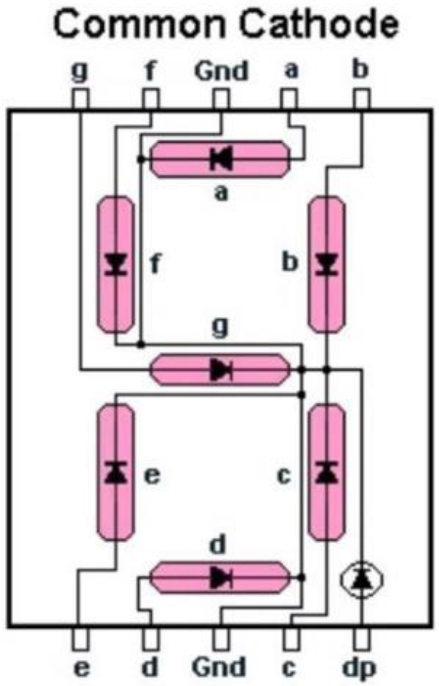


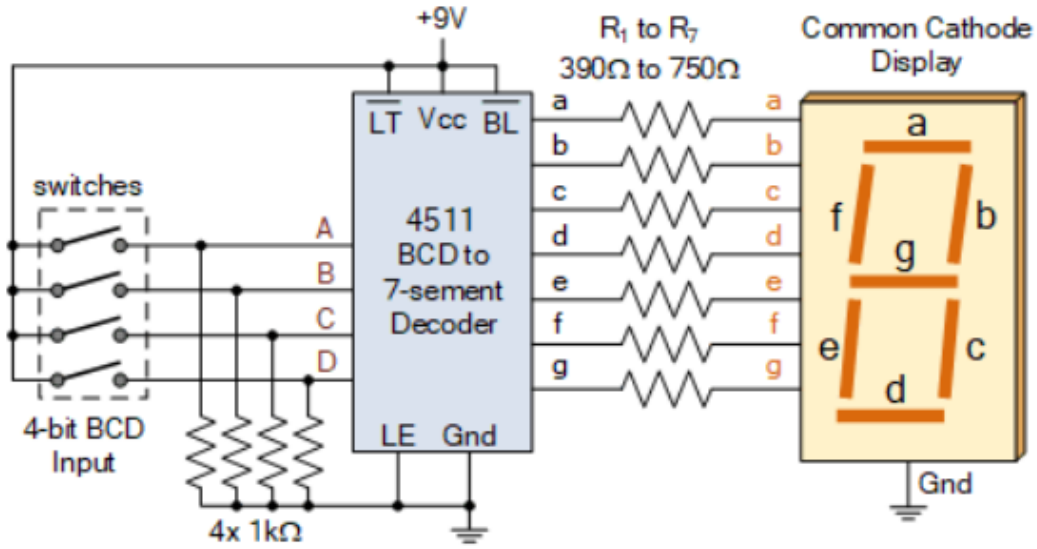


DECODER CIRCUIT

- BCD to 7 segment decoder (common cathode connection):



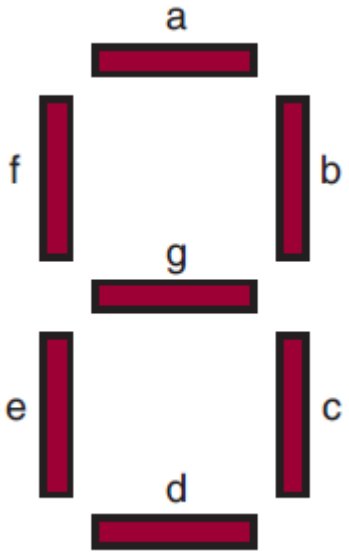


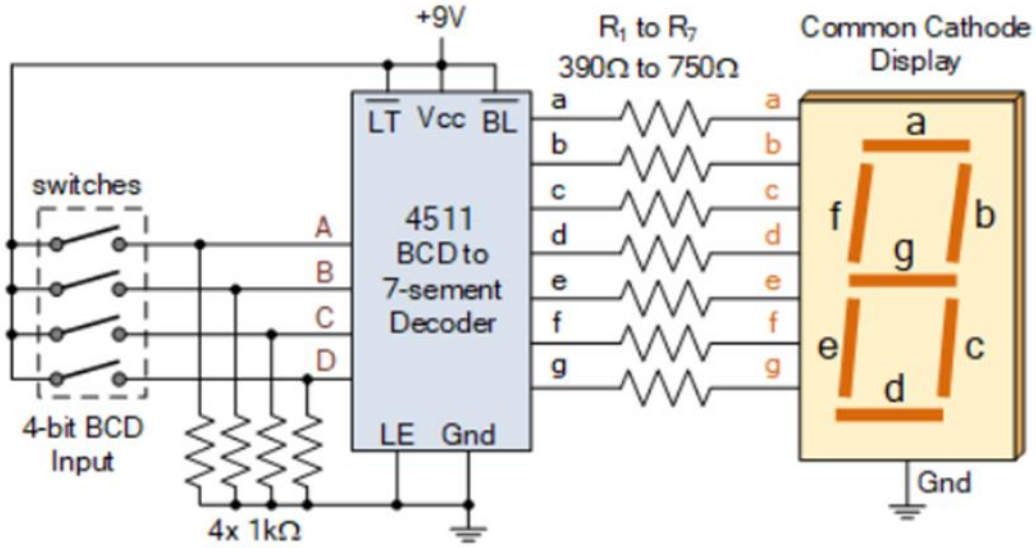


DECODER CIRCUIT

- BCD to 7 segment decoder (common cathode connection):

Decimal	*a*	*b*	*c*	*d*	*e*	*f*	*g*
0	1	1	1	1	1	1	0
1	0	1	1	0	0	0	0
2	1	1	0	1	1	0	1
3	1	1	1	1	0	0	1
4	0	1	1	1	0	1	1
5	1	0	1	1	0	1	1
6	1	0	1	1	1	1	1
7	1	1	1	1	0	0	0
8	1	1	1	1	1	1	1
9	1	1	1	1	0	1	1





Decimal	*A*	*B*	*C*	*D*	*a*	*b*	*c*	*d*	*e*	*f*	*g*
10	1	0	1	0	X	X	X	X	X	X	X
11	1	0	1	1	X	X	X	X	X	X	X
12	1	1	0	0	X	X	X	X	X	X	X
13	1	1	0	1	X	X	X	X	X	X	X
14	1	1	1	0	X	X	X	X	X	X	X
15	1	1	1	1	X	X	X	X	X	X	X

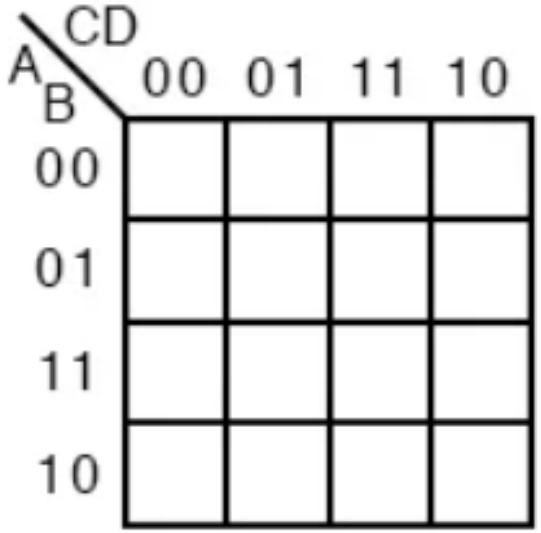
$$a = \sum m\,(0, 2, 3, 5, 7, 8, 9) + \sum d\,(10, 11, 12, 13, 14, 15)$$
$$b = \sum m\,(0, 1, 2, 3, 4, 7, 8, 9) + \sum d\,(10, 11, 12, 13, 14, 15)$$
$$c = \sum m\,(0, 1, 3, 4, 5, 6, 7, 8, 9) + \sum d\,(10, 11, 12, 13, 14, 15)$$
$$d = \sum m\,(0, 2, 3, 5, 6, 8) + \sum d\,(10, 11, 12, 13, 14, 15)$$
$$e = \sum m\,(0, 2, 6, 8) + \sum d\,(10, 11, 12, 13, 14, 15)$$
$$f = \sum m\,(0, 4, 5, 6, 8, 9) + \sum d\,(10, 11, 12, 13, 14, 15)$$
$$g = \sum m\,(2, 3, 4, 5, 6, 8, 9) + \sum d\,(10, 11, 12, 13, 14, 15)$$

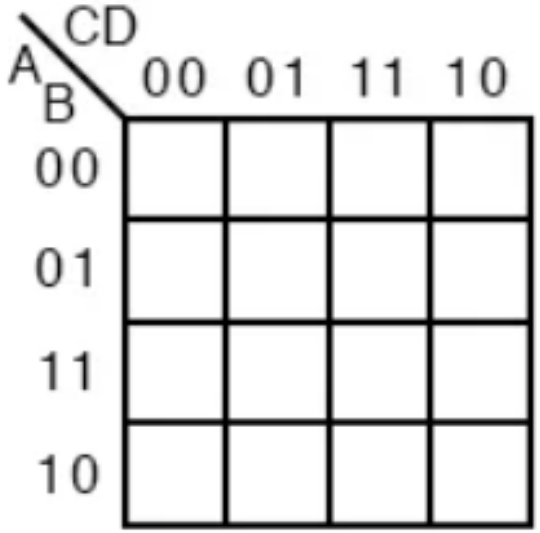
DECODER CIRCUIT

- BCD to 7 segment decoder (common anode connection):

$$a = \sum m\,(0, 2, 3, 5, 7, 8, 9) + \sum d\,(10, 11, 12, 13, 14, 15)$$
$$b = \sum m\,(0, 1, 2, 3, 4, 7, 8, 9) + \sum d\,(10, 11, 12, 13, 14, 15)$$
$$c = \sum m\,(0, 1, 3, 4, 5, 6, 7, 8, 9) + \sum d\,(10, 11, 12, 13, 14, 15)$$
$$d = \sum m\,(0, 2, 3, 5, 6, 8) + \sum d\,(10, 11, 12, 13, 14, 15)$$
$$e = \sum m\,(0, 2, 6, 8) + \sum d\,(10, 11, 12, 13, 14, 15)$$
$$f = \sum m\,(0, 4, 5, 6, 8, 9) + \sum d\,(10, 11, 12, 13, 14, 15)$$
$$g = \sum m\,(2, 3, 4, 5, 6, 8, 9) + \sum d\,(10, 11, 12, 13, 14, 15)$$

$$a = A + BD + \overline{B}\,\overline{D} + \overline{B}C$$
$$b = B + \overline{C}\,\overline{D} + CD$$
$$c = B + \overline{C} + D$$
$$d = C\overline{D} + \overline{B}C + B\overline{C}D + \overline{B}\,\overline{D}$$
$$e = C\overline{D} + \overline{B}\,\overline{D}$$
$$f = A + \overline{C}\,\overline{D} + B\overline{C} + B\overline{D}$$
$$g = A + B\overline{C} + C\overline{D} + \overline{B}C$$





DECODER CIRCUIT

- BCD to 7 segment decoder (common anode connection):

$$a = \sum m\,(0, 2, 3, 5, 7, 8, 9) + \sum d\,(10, 11, 12, 13, 14, 15)$$
$$b = \sum m\,(0, 1, 2, 3, 4, 7, 8, 9) + \sum d\,(10, 11, 12, 13, 14, 15)$$
$$c = \sum m\,(0, 1, 3, 4, 5, 6, 7, 8, 9) + \sum d\,(10, 11, 12, 13, 14, 15)$$
$$d = \sum m\,(0, 2, 3, 5, 6, 8) + \sum d\,(10, 11, 12, 13, 14, 15)$$
$$e = \sum m\,(0, 2, 6, 8) + \sum d\,(10, 11, 12, 13, 14, 15)$$
$$f = \sum m\,(0, 4, 5, 6, 8, 9) + \sum d\,(10, 11, 12, 13, 14, 15)$$
$$g = \sum m\,(2, 3, 4, 5, 6, 8, 9) + \sum d\,(10, 11, 12, 13, 14, 15)$$

$$a = A + BD + \overline{B}\,\overline{D} + \overline{B}C$$
$$b = B + \overline{C}\,\overline{D} + CD$$
$$c = B + \overline{C} + D$$
$$d = C\overline{D} + \overline{B}C + B\overline{C}D + \overline{B}\,\overline{D}$$
$$e = C\overline{D} + \overline{B}\,\overline{D}$$
$$f = A + \overline{C}\,\overline{D} + B\overline{C} + B\overline{D}$$
$$g = A + B\overline{C} + C\overline{D} + \overline{B}C$$