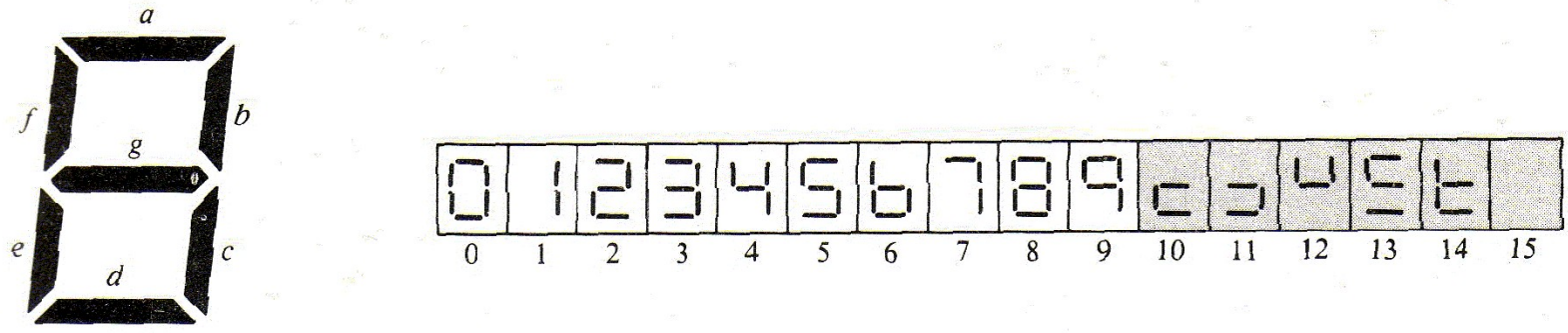
Homework

- Reading
  - Tokheim, Section 5-10, 7-4
- Machine Projects
  - Continue on MP4
- Labs
  - Continue labs with your assigned section

Seven Segment Display

- Used for output of a single decimal digit
- Driven by a binary coded decimal (BCD) nibble
- A separate set of combinational logic turns on or off each segment to create the digit display

Seven Segment Display

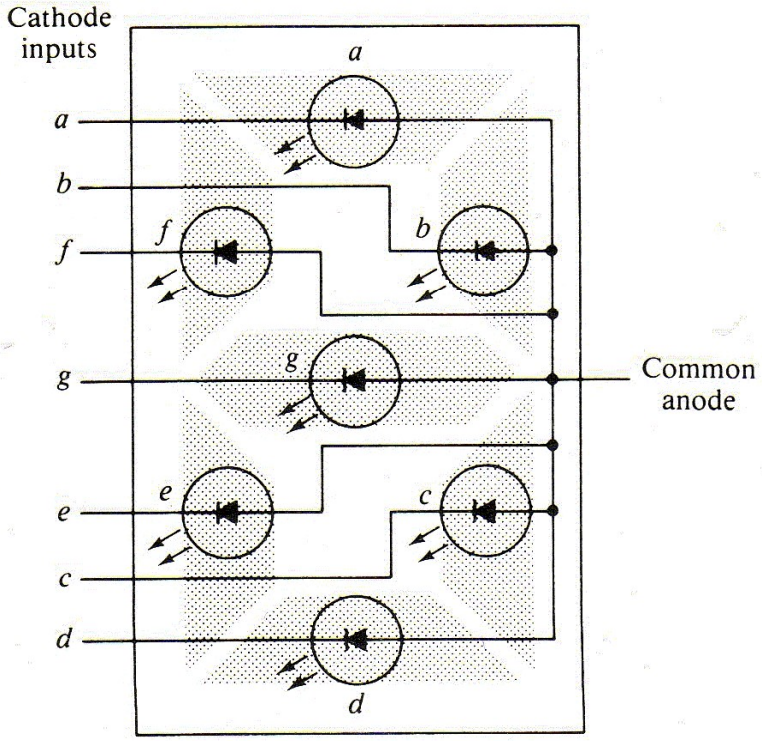


(*a*) Segment identification

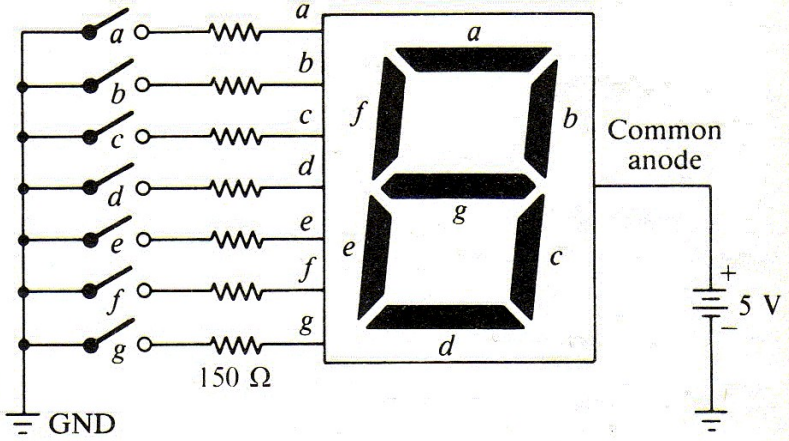
(*b*) Decimal number with typical display

Fig. 7-10 Seven-segment display

Seven Segment Display



(*b*) Wiring of seven-segment LED display



(*c*) Operating seven-segment LED display

Fig. 7-11

Seven Segment Display

- Seven Segment Display Driver

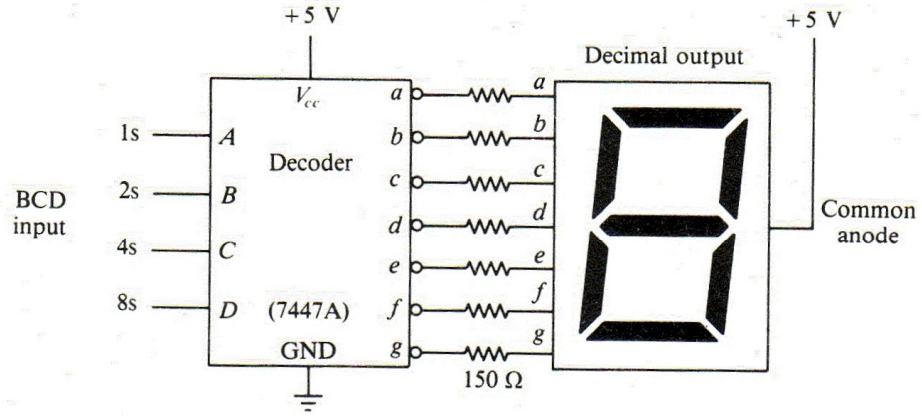


Fig. 7-13 Wiring of decoder and seven-segment LED display

Seven Segment Display

- Truth Table for Seven Segment Display Driver

Decimal or function	Inputs						*BI/RBO*	Outputs							Note
	LT	*RBI*	*D*	*C*	*B*	*A*		*a*	*b*	*c*	*d*	*e*	*f*	*g*	
0	H	H	L	L	L	L	H	ON	ON	ON	ON	ON	ON	OFF	1
1	H	X	L	L	L	H	H	OFF	ON	ON	OFF	OFF	OFF	OFF	
2	H	X	L	L	H	L	H	ON	ON	OFF	ON	ON	OFF	ON	
3	H	X	L	L	H	H	H	ON	ON	ON	ON	OFF	OFF	ON	
4	H	X	L	H	L	L	H	OFF	ON	ON	OFF	OFF	ON	ON	
5	H	X	L	H	L	H	H	ON	OFF	ON	ON	OFF	ON	ON	
6	H	X	L	H	H	L	H	OFF	OFF	ON	ON	ON	ON	ON	
7	H	X	L	H	H	H	H	ON	ON	ON	OFF	OFF	OFF	OFF	
8	H	X	H	L	L	L	H	ON	ON	ON	ON	ON	ON	ON	
9	H	X	H	L	L	H	H	ON	ON	ON	OFF	OFF	ON	ON	
10	H	X	H	L	H	L	H	OFF	OFF	OFF	ON	ON	OFF	ON	
11	H	X	H	L	H	H	H	OFF	OFF	ON	ON	OFF	OFF	ON	
12	H	X	H	H	L	L	H	OFF	ON	OFF	OFF	OFF	ON	ON	
13	H	X	H	H	L	H	H	ON	OFF	OFF	ON	OFF	ON	ON	
14	H	X	H	H	H	L	H	OFF	OFF	OFF	ON	ON	ON	ON	
15	H	X	H	H	H	H	H	OFF	OFF	OFF	OFF	OFF	OFF	OFF	

Seven Segment Display Logic

- Seven combinational logic circuits - one for each segment
- Look at the logic for segment e – when is it on?

A	B	C	D	Sum of Product Terms
L	L	L	L	$\overline{A}\,\overline{B}\,\overline{C}\,\overline{D}$
L	L	H	L	$\overline{A}\,\overline{B}\,C\,\overline{D}$
L	H	H	L	$\overline{A}\,B\,C\,\overline{D}$
H	L	L	L	$A\,\overline{B}\,\overline{C}\,\overline{D}$

- How to factor this sum in order to simplify?

Karnaugh Map for Segment e

- Put down all the 1's for D, C, B, A = 0 through 9
- Then, fill in 0's for all other valid BCD input values

	$\overline{C}\,\overline{D}$	$\overline{C}\,D$	$C\,D$	$C\,\overline{D}$
$\overline{A}\,\overline{B}$	**1**	**0**	**0**	**1**
$\overline{A}\,B$	**0**	**0**	**0**	**1**
$A\,B$				
$A\,\overline{B}$	**1**	**0**		

Don’t Cares in Karnaugh Map

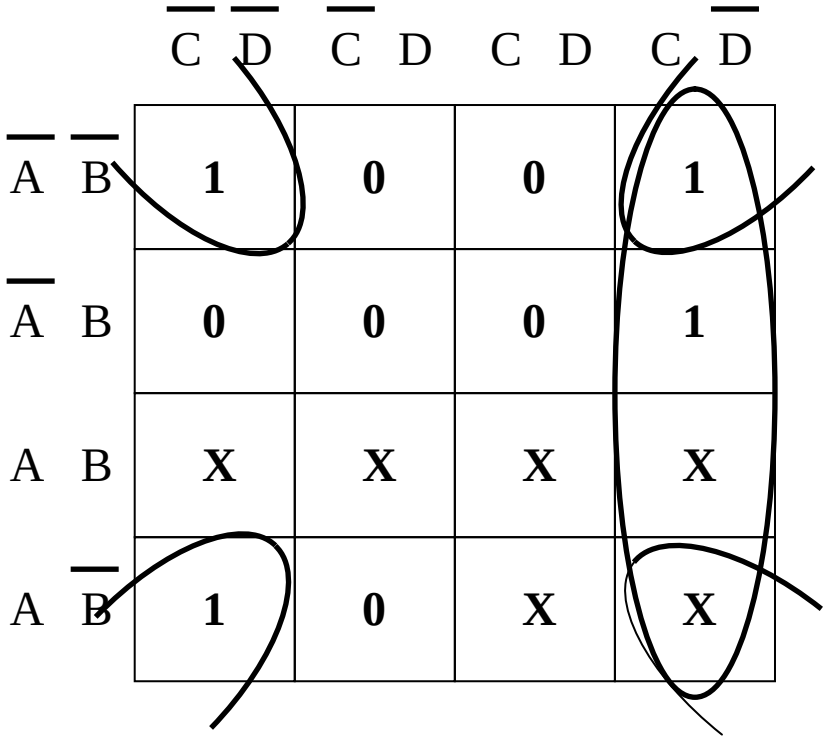
- That takes care of 10 out of 16 combinations
- What about the other 6? They are “don’t cares”

	$\overline{C}\,\overline{D}$	$\overline{C}\,D$	$C\,D$	$C\,\overline{D}$
$\overline{A}\,\overline{B}$	**1**	**0**	**0**	**1**
$\overline{A}\,B$	**0**	**0**	**0**	**1**
$A\,B$	**X**	**X**	**X**	**X**
$A\,\overline{B}$	**1**	**0**	**X**	**X**

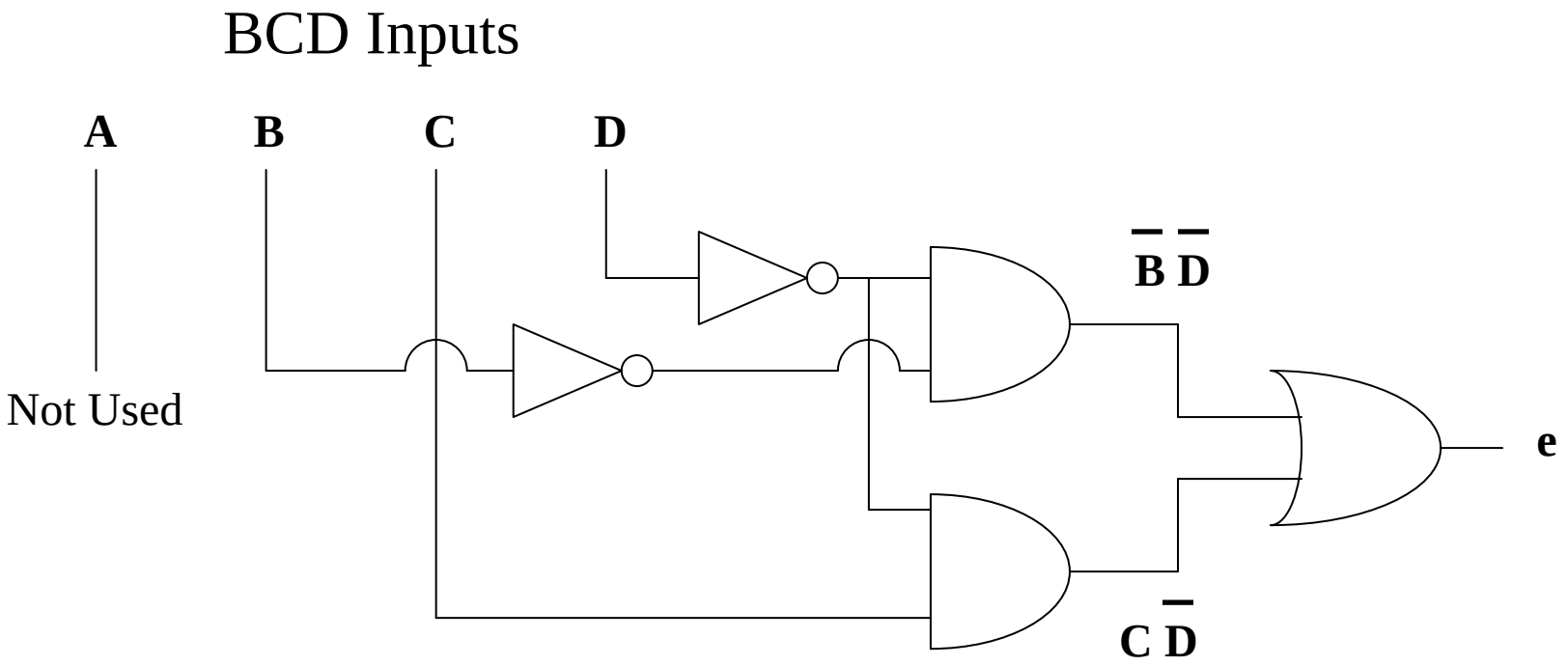
Karnaugh Map for Segment e

- Now we loop the largest areas that we can
- Use “don’t cares” as 1’s if loops can be larger

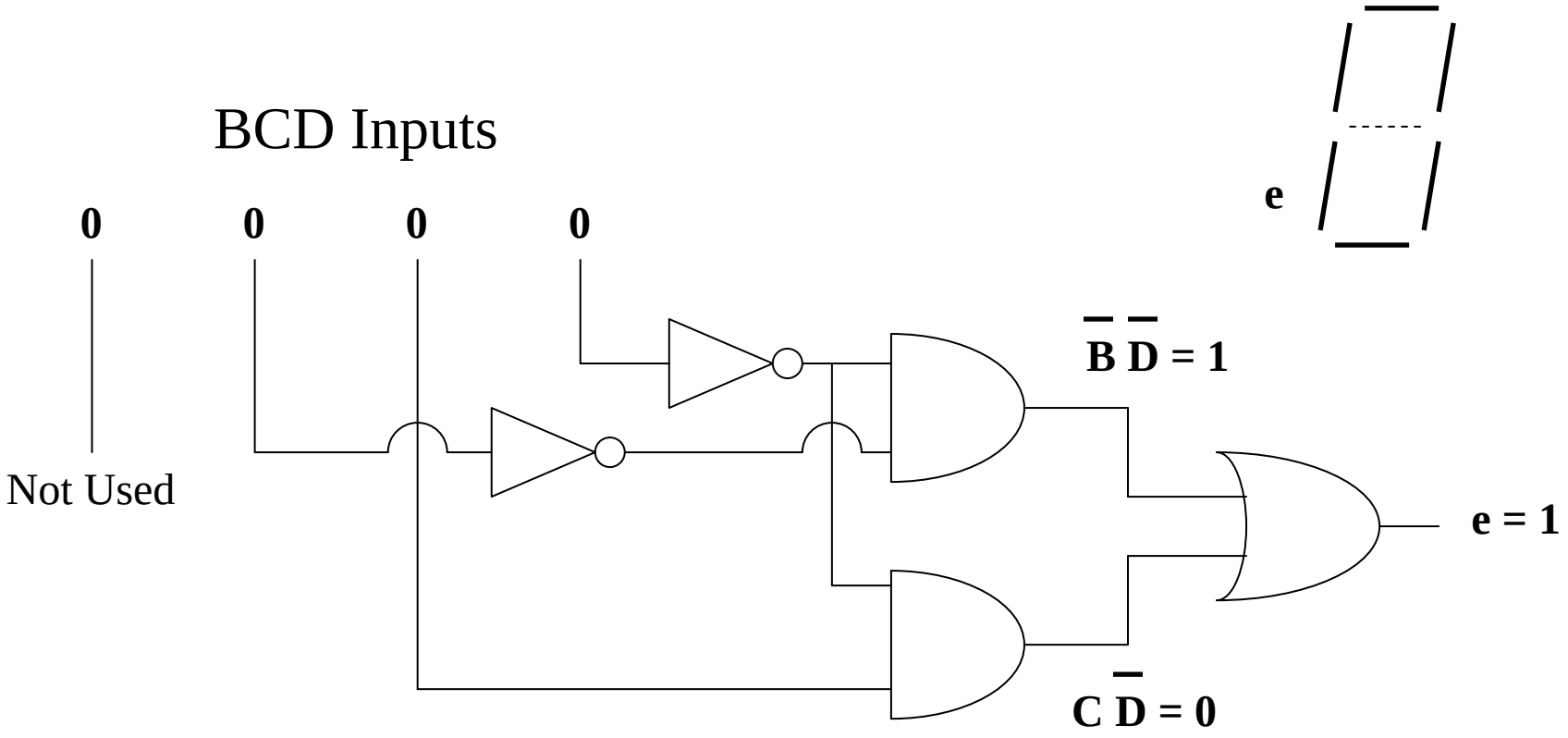
Segment e = $\overline{B}\,\overline{D} + C\,\overline{D}$



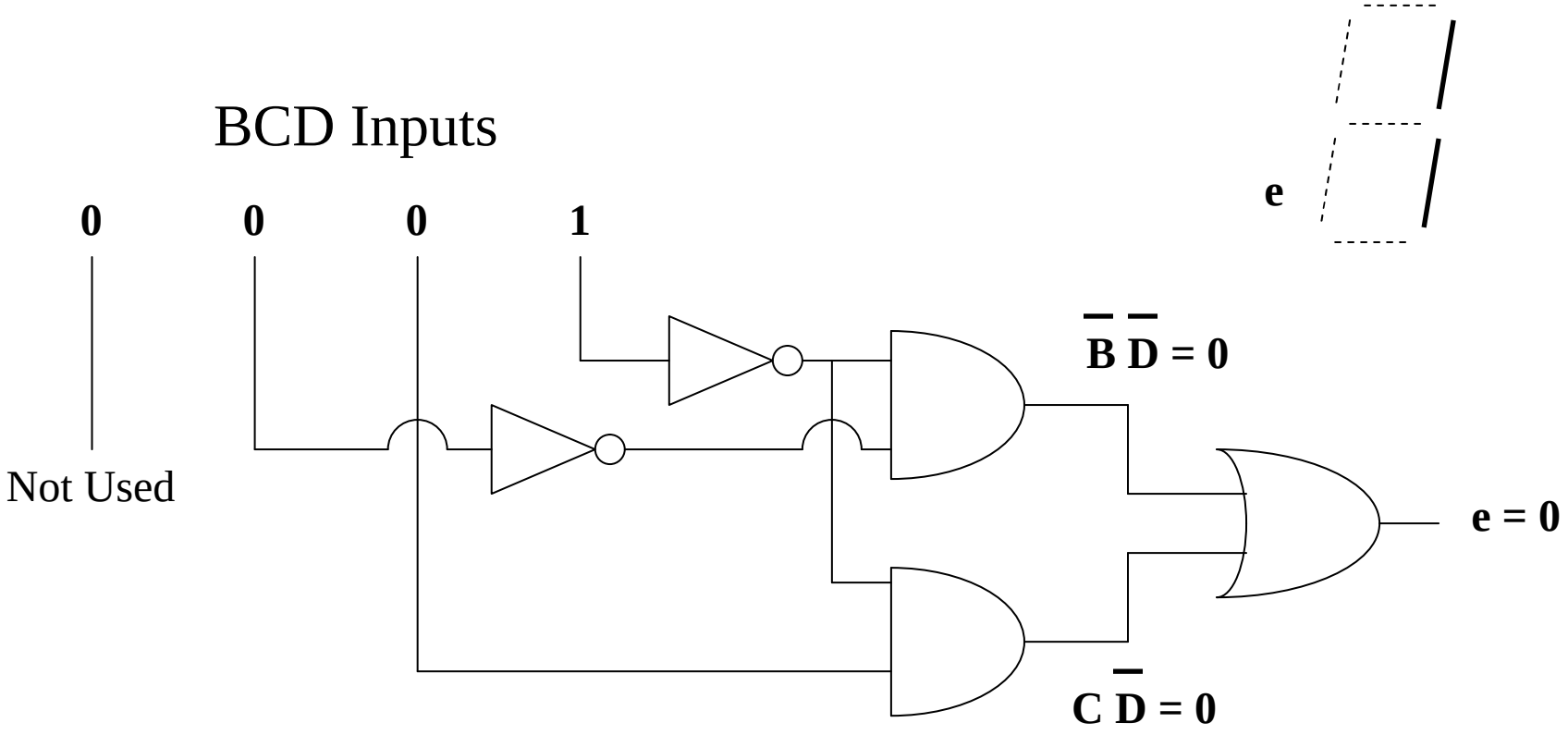
Segment e Logic Circuit



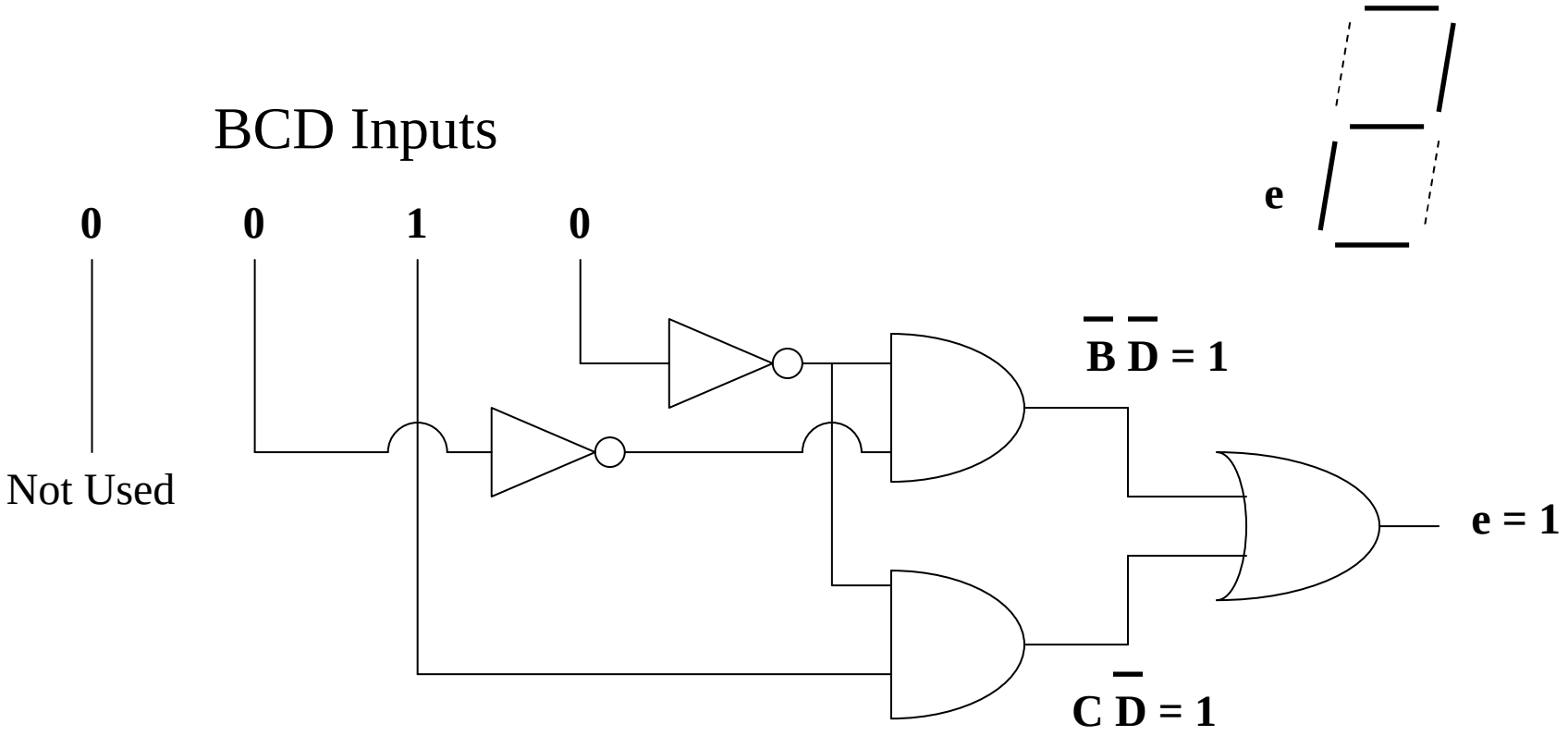
Test Segment e Logic Circuit



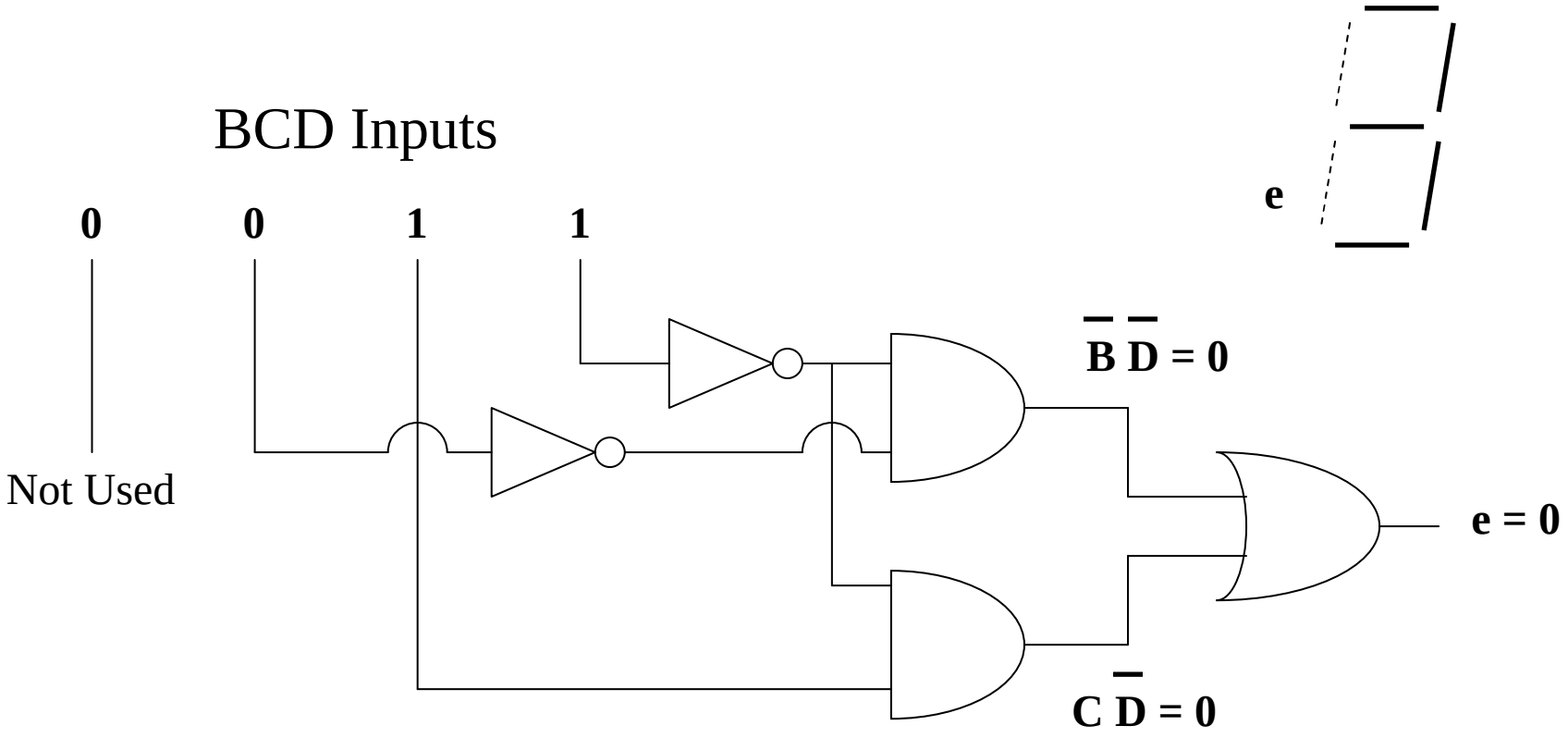
Test Segment e Logic Circuit



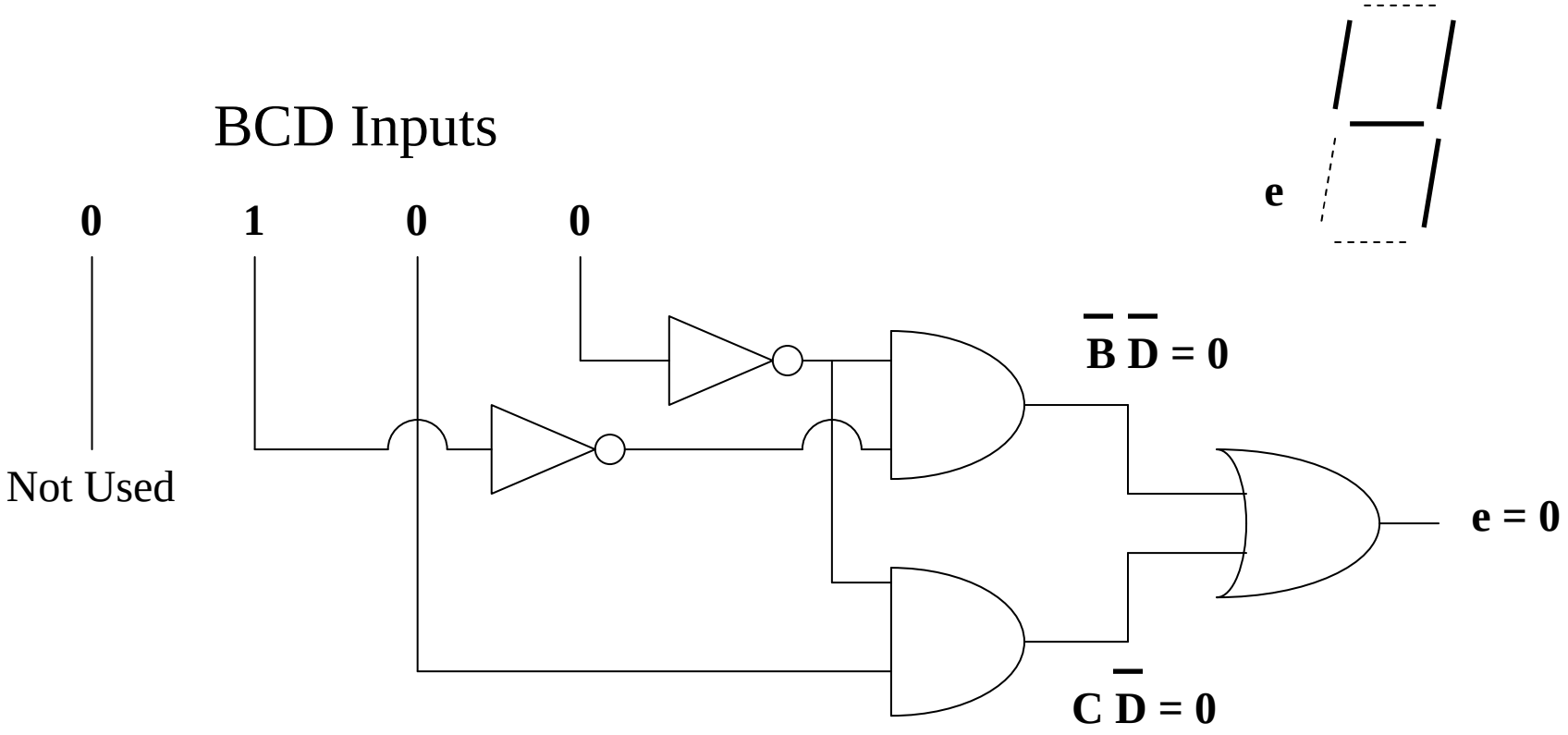
Test Segment e Logic Circuit



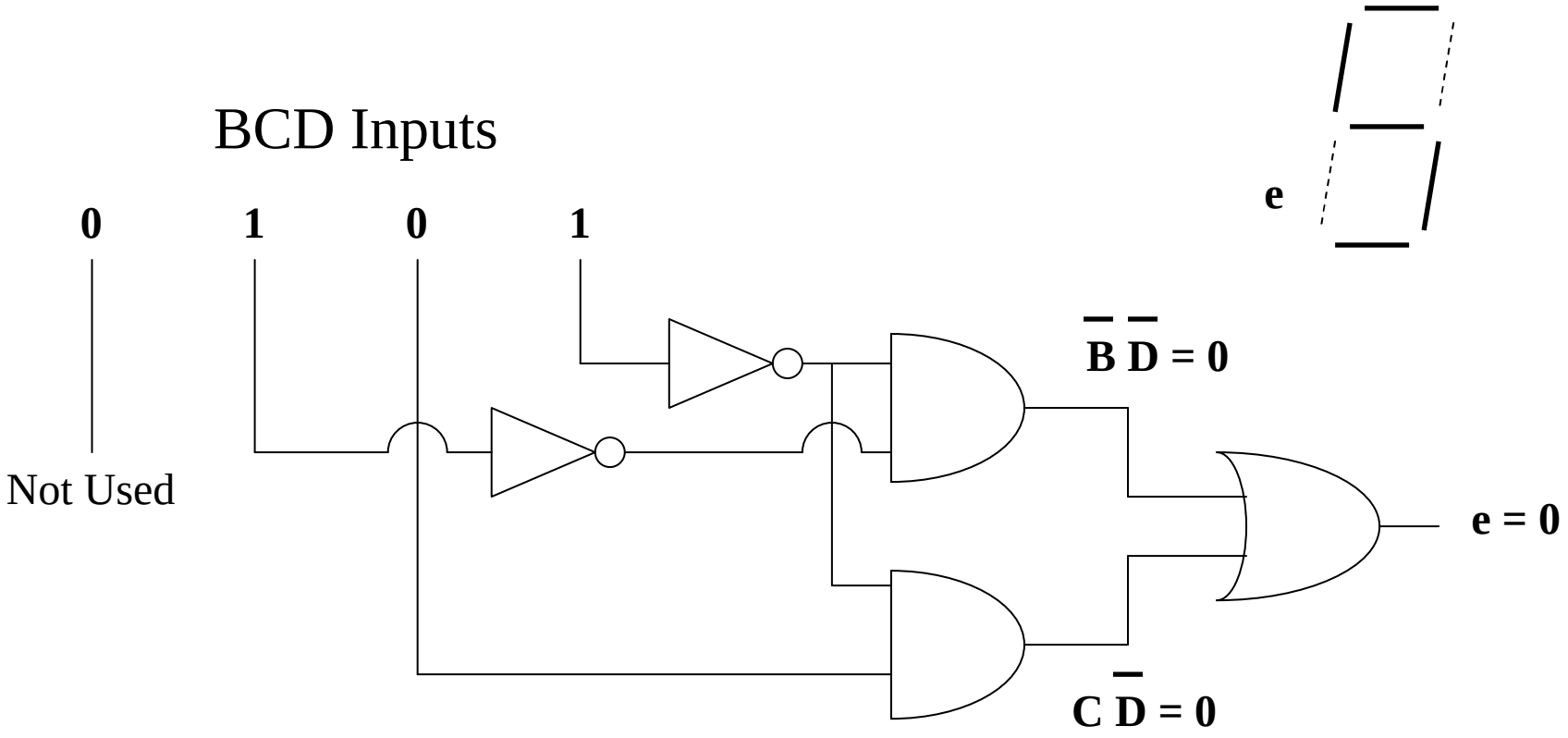
Test Segment e Logic Circuit



Test Segment e Logic Circuit



Test Segment e Logic Circuit



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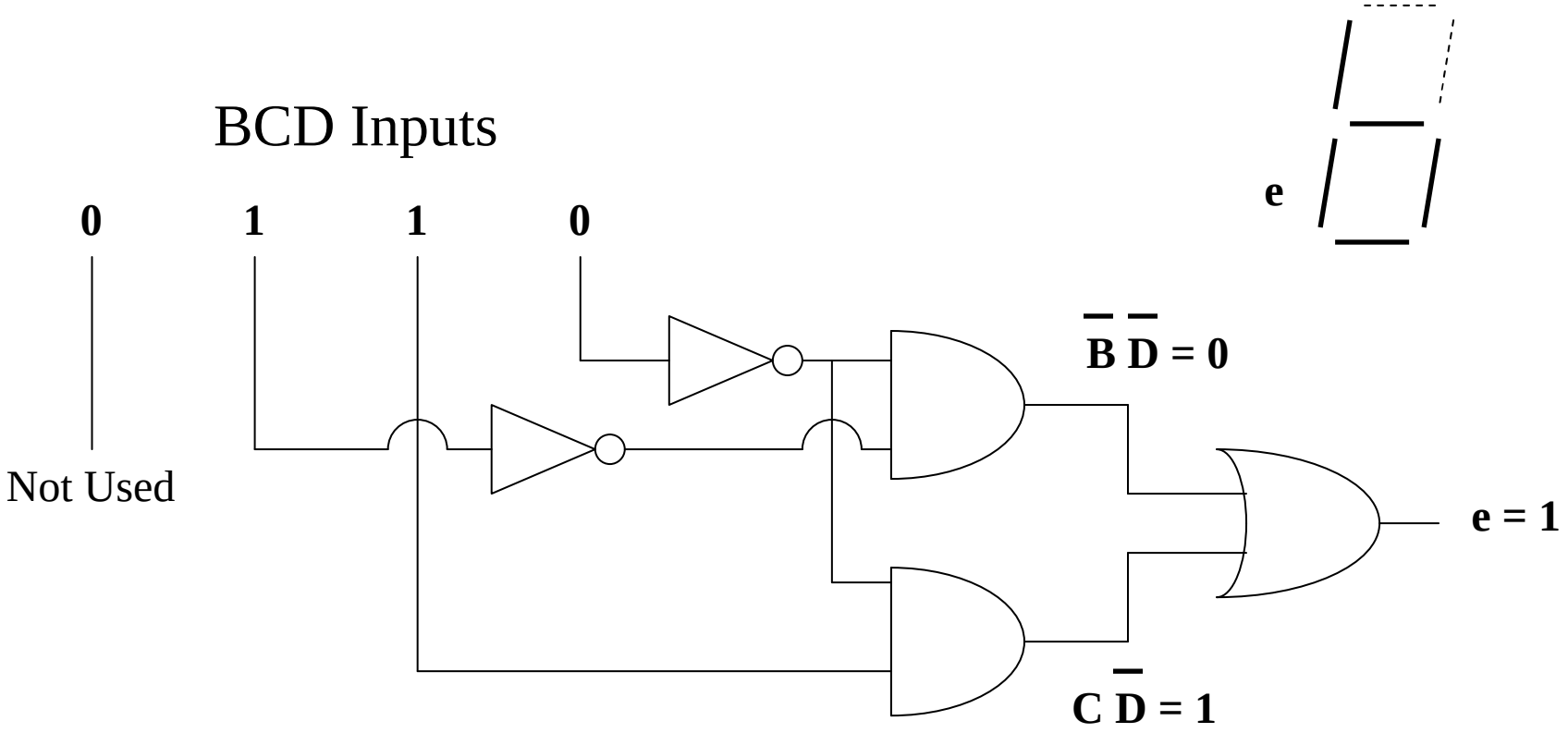
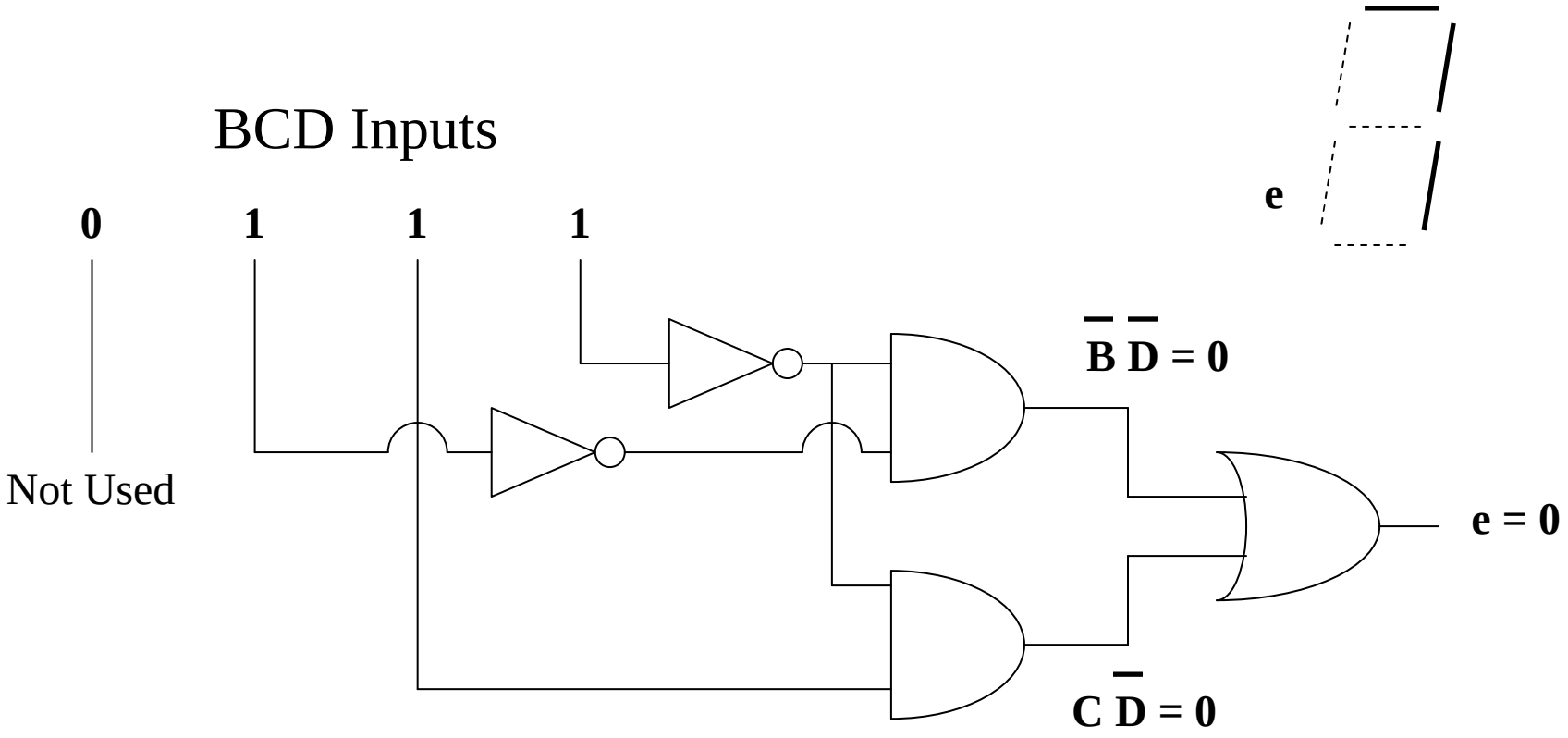


Test Segment e Logic Circuit



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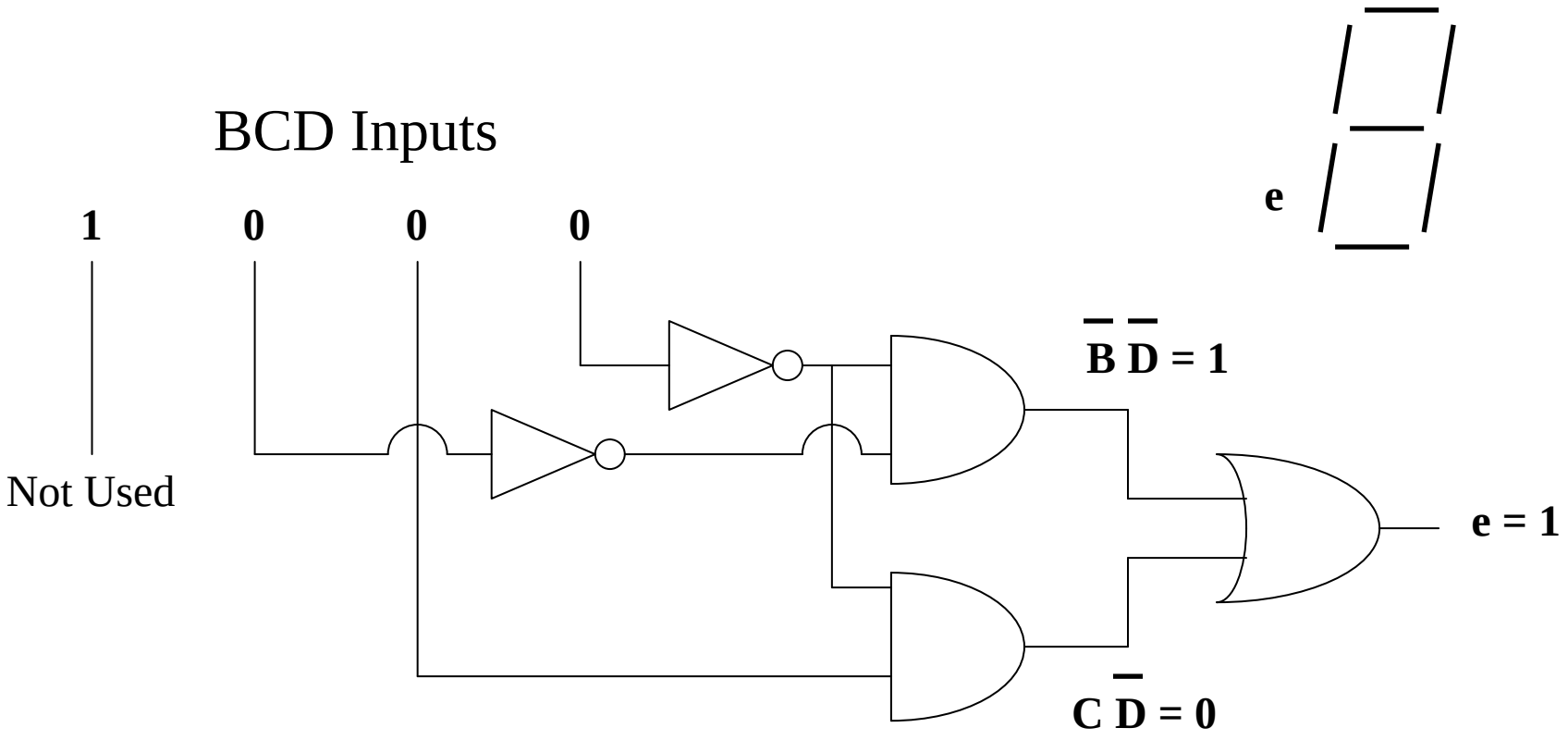

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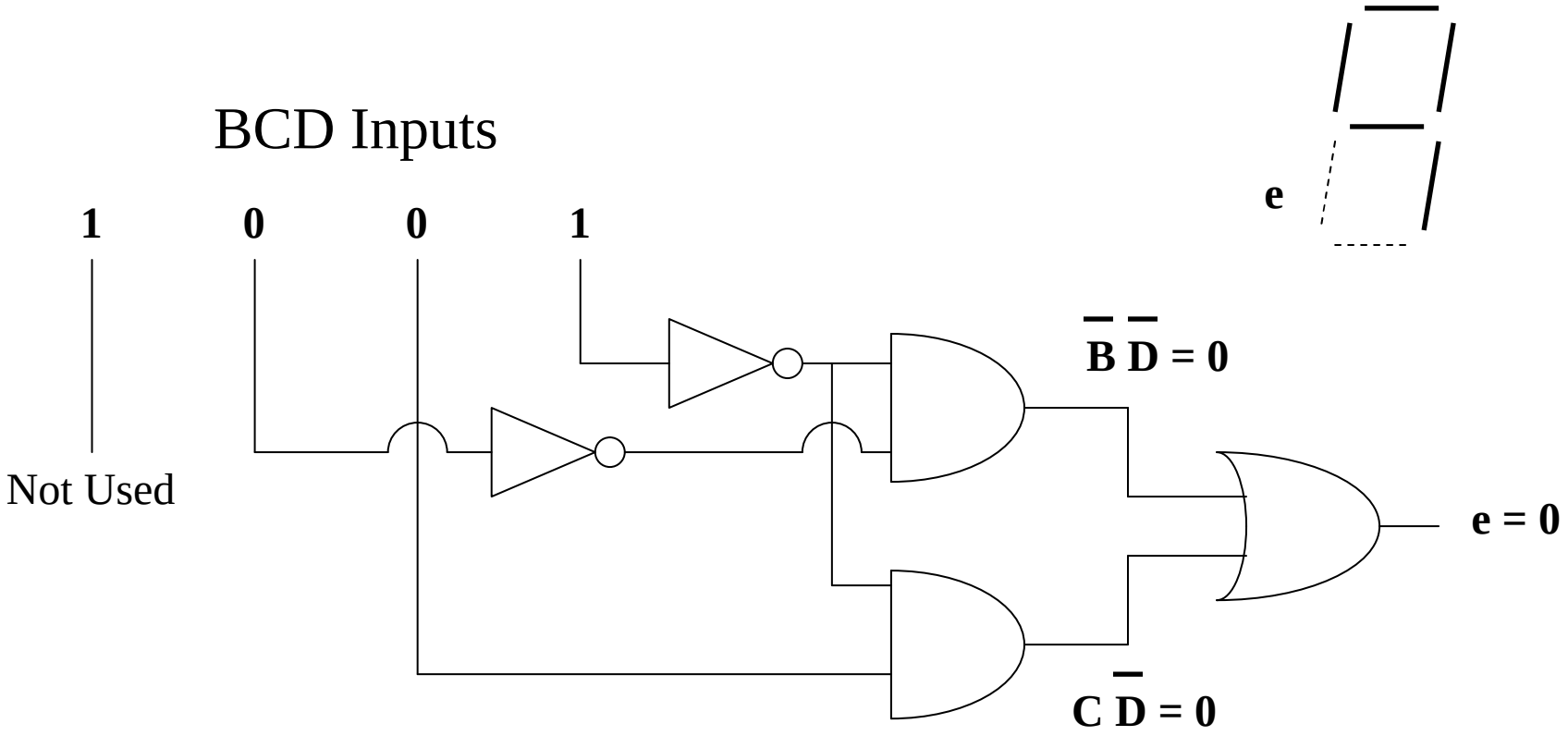
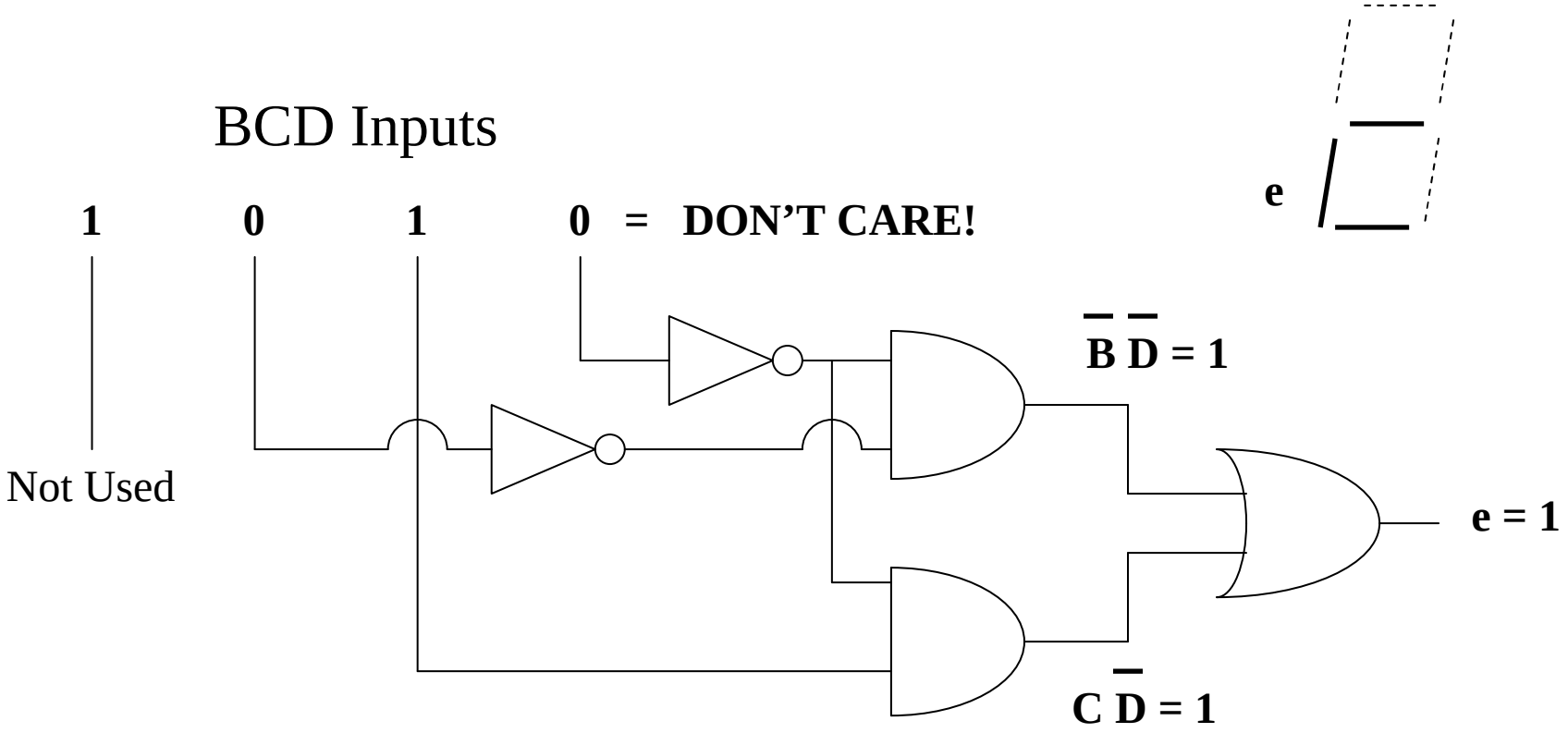


Test Segment e Logic Circuit



Can we do better than the map result?

- Sometimes, if we look at the Boolean equation from the Karnaugh map for segment e:

  Segment e = $\overline{B}\ \overline{D} + C\ \overline{D}$

  It can be factored:

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

- Simpler Logic Diagram (Product of Sums):