

Massachusetts Institute of Technology

Department of Electrical Engineering and Computer Science

6.111 – Introductory Digital Systems Laboratory

Problem Set 1 Solutions

Problem 1:

Not graded.

Problem 2:

For each of the following Boolean expressions, give:

- i) the truth table
- ii) the Karnaugh map
- iii) the MSP expression (show groupings)
- iv) the MPS expression (show groupings)

1. $y\bar{z} + \bar{y}(x+z)$

i)

x	y	z	
0	0	0	0
0	0	1	1
0	1	0	1
0	1	1	0
1	0	0	1
1	0	1	1
1	1	0	1
1	1	1	0

ii)

		yz	00	01	11	10
x	0		0	1	0	1
	1		1	1	0	1

iii) $\bar{y}z + x\bar{y} + y\bar{z}$

		yz	00	01	11	10
x	0		0	1	0	1
	1		1	1	0	1

or $\bar{y}z + x\bar{z} + y\bar{z}$

		yz	00	01	11	10
x	0		0	1	0	1
	1		1	1	0	1

iv) $(\bar{y} + \bar{z})(x + y + z)$

		yz			
		00	01	11	10
x	0	0	1	0	1
	1	1	1	0	1

2. $\bar{b}cd + \bar{a}bc + acd + \bar{a}\bar{c}d$

i)

a	b	c	d	
0	0	0	0	0
0	0	0	1	1
0	0	1	0	0
0	0	1	1	1
0	1	0	0	0
0	1	0	1	1
0	1	1	0	1
0	1	1	1	1
1	0	0	0	0
1	0	0	1	0
1	0	1	0	0
1	0	1	1	1
1	1	0	0	0
1	1	0	1	0
1	1	1	0	0
1	1	1	1	1

ii)

		cd			
		00	01	11	10
ab	00	0	1	1	0
	01	0	1	1	1
	11	0	0	1	0
	10	0	0	1	0

iii) $(c * d) + (\bar{a} * b * c) + (\bar{a} * d)$

		cd			
ab		00	01	11	10
00	0	1	1	0	
01	0	1	1	1	
11	0	0	1	0	
10	0	0	1	0	

iv) $(c + d)(b + d)(\bar{a} + d)(\bar{a} + c)$

		cd			
ab		00	01	11	10
00	0	1	1	0	
01	0	1	1	1	
11	0	0	1	0	
10	0	0	1	0	

Problem 3:

1.

		ab			
cd		00	01	11	10
00	1	1	1	1	
01	0	1	X	0	
11	0	0	X	0	
10	1	0	0	1	

MSP: $\bar{b}c + \bar{b}\bar{d}$

		ab			
cd		00	01	11	10
00	1	1	1	1	
01	0	1	X	0	
11	0	0	X	0	
10	1	0	0	1	

MPS: $(b + \bar{d})(\bar{c} + \bar{b})$

The solutions are unique:

The MSP equals the MPS since the top X is always treated as a '1' and the bottom X is always treated as a '0'.

2.

		ab			
		00	01	11	10
cd	00	0	1	1	1
	01	0	0	0	X
	11	1	1	0	1
	10	1	1	0	1

MSP: $\overline{bcd} + \overline{ab} + \overline{ac}$

		ab			
		00	01	11	10
cd	00	0	1	1	1
	01	0	0	0	X
	11	1	1	0	1
	10	1	1	0	1

MPS: $(c + \overline{d})(a + b + c)(\overline{a} + \overline{b} + \overline{c})$

Yes, the solutions are unique

No, the MSP does not equal the MPS because the X is used as a '1' in the MSP and a '0' in the MPS.

Problem 4:

$$\overline{\overline{abc}} = \overline{a + b + c}$$

$$\overline{\overline{\overline{a + c + b + d}}} = \overline{\overline{abc + acd}}$$

Problem 5:

p5.vhd

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library ieee;
use ieee.std_logic_1164.all;

entity p5 is port (a, b, c, d : in std_logic;
                  p1, p2 : out std_logic);

end p5;

architecture calc of p5 is
begin
    p1 <= (a and c) or ((not a) and (b or (not c)));
    p2 <= ((not b) and (not c) and d) or ((not a) and b and d)
          or (a and (not c) and d) or ((not a) and (not c) and (not d));
end calc;

```

taken from p5.rpt

DESIGN EQUATIONS

$$\begin{aligned} /p1 &= \\ & \quad /a * /b * c \\ & \quad + /a * c \end{aligned}$$

$$\begin{aligned} /p2 &= \\ & \quad /a * b * d \\ & \quad + /c * d \\ & \quad + /a * /c \end{aligned}$$

Completed Successfully