Ministerul Educaţiei și Cercetării al Republicii Moldova
Universitatea Tehnică a Moldovei
Facultatea Calculatoare, Informatică și Microelectronică

Computer Architecture

Laboratory work 1: Binary Arithmetic

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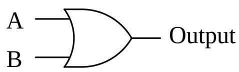
Chişinău - 2023

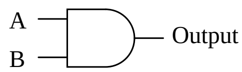
Answer 1

OR



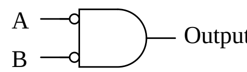
A	B	Output
0	0	0
0	1	1
1	0	1
1	1	1

AND



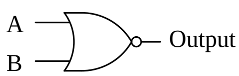
A	B	Output
0	0	0
0	1	0
1	0	0
1	1	1

Neg-AND



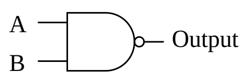
A	B	Output
0	0	1
0	1	0
1	0	0
1	1	0

NOR



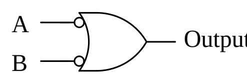
A	B	Output
0	0	1
0	1	0
1	0	0
1	1	0

NAND



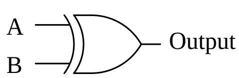
A	B	Output
0	0	1
0	1	1
1	0	1
1	1	0

Neg-OR



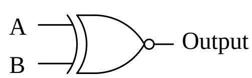
A	B	Output
0	0	1
0	1	1
1	0	1
1	1	0

XOR



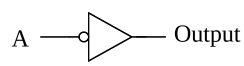
A	B	Output
0	0	0
0	1	1
1	0	1
1	1	0

XNOR



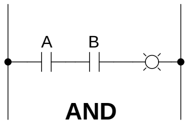
A	B	Output
0	0	1
0	1	0
1	0	0
1	1	1

NOT



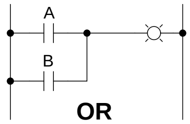
A	Output
0	1
1	0

Answer 2



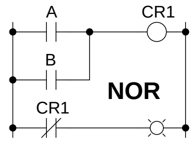
AND

A	B	Output
0	0	0
0	1	0
1	0	0
1	1	1



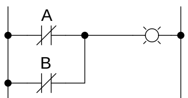
OR

A	B	Output
0	0	0
0	1	1
1	0	1
1	1	1



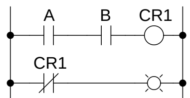
NOR

A	B	Output
0	0	1
0	1	0
1	0	0
1	1	0



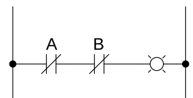
Neg-OR

A	B	Output
0	0	1
0	1	1
1	0	1
1	1	0



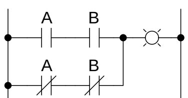
NAND

A	B	Output
0	0	1
0	1	1
1	0	1
1	1	0



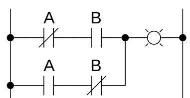
Neg-AND

A	B	Output
0	0	1
0	1	0
1	0	0
1	1	0



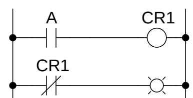
XNOR

A	B	Output
0	0	1
0	1	0
1	0	0
1	1	1



XOR

A	B	Output
0	0	0
0	1	1
1	0	1
1	1	0



NOT

A	Output
0	1
1	0

Answer 3

AB \ C	0	1
00	1	1
01	0	1
11	0	0
10	0	1

Answer 4

AB \ CD	00	01	11	10
00	0	1	0	0
01	0	1	0	0
11	0	1	1	0
10	0	1	1	1

Answer 5

For this group of four 1's, only variables A and C alter while variables B and D stay constant with a value of 1 for all four instances of a "high" output.

Answer 6

For this set of four 1's, variables A and B are the only inputs that maintain a constant state throughout the four instances of a "1" in the Karnaugh map. The simplified Boolean expression for the truth table is represented as AB.

Answer 7

AB \ CD	00	01	10	11
00	0	0	0	0
01	0	1	0	1
10	0	0	0	0
11	0	1	0	1

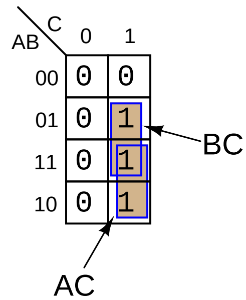
Examining this, it's still evident that B = 1 and D = 1 for all four instances of a "high" output. However, this is not as obvious through proximity as it was previously.

Answer 8

AB \ CD	00	01	11	10	00	01	11	10
00	1	0	0	1	1	0	0	1
01	0	0	0	0	0	0	0	0
11	0	0	0	0	0	0	0	0
10	1	0	0	1	1	0	0	1
00	1	0	0	1	1	0	0	1
01	0	0	0	0	0	0	0	0
11	0	0	0	0	0	0	0	0
10	1	0	0	1	1	0	0	1

Answer 9

Proper grouping of 1's in the Karnaugh map:



Answer 10

There are a few rules to follow when properly identifying common groups in a Karnaugh map:

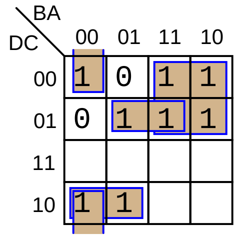
- Adjacent cells: Common groups must be formed of adjacent cells in the Karnaugh map. These cells can be in a horizontal, vertical, or diagonal pattern.
- Size of groups: Common groups can only contain a maximum of two cells in a two-variable map, four cells in a three-variable map, and so on.
- Continuity: Common groups must be connected and form a continuous pattern without any interruptions.
- No overlap: Common groups must not overlap with one another, meaning each cell can only belong to one group.

By following these rules, you can accurately and efficiently identify the common groups in a Karnaugh map, which can help simplify and minimize the expression of a logic circuit.

Answer 11

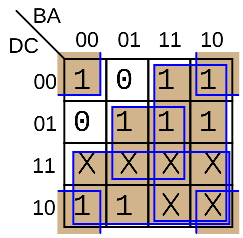
Karnaugh map groupings with strict "1" groups:

$$\overline{D}B + \overline{D}CA + D\overline{C}\,\overline{B} + \overline{C}\,\overline{B}\,\overline{A}$$



Karnaugh map groupings with "don't care" wildcards:

$$D + B + CA + \overline{C}\,\overline{A}$$



This question and answer merely focused on the a output for the BCD-to-7-segment decoder circuit. Imagine if we were to approach all seven outputs of the decoder circuit in these two fashions, first developing SOP expressions using strict groupings of "1" outputs, and then using "don't care" wildcards.

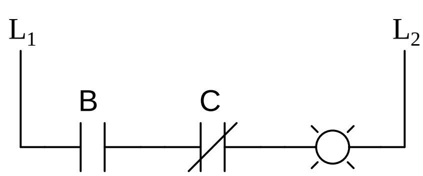
Answer 12

Yes, you can use Karnaugh maps to generate POS expressions, not just SOP expressions!

Answer 13

Simple expression and relay circuit:

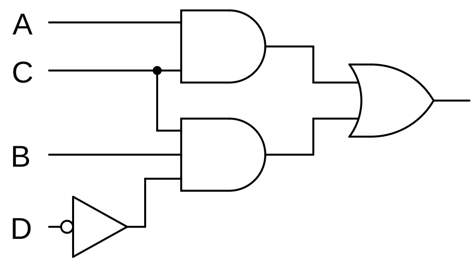
$$B\overline{C}$$



Answer 14

Simple expression and gate circuit:

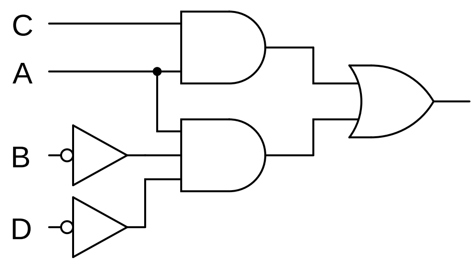
$$AC + BC\overline{D}$$



Answer 15

Simple expression and gate circuit:

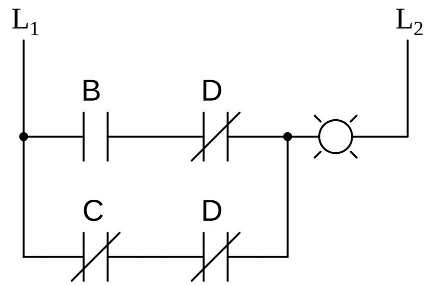
$$AC + A\overline{B}\,\overline{D}$$



Answer 16

Simple expression and relay circuit:

$$B\overline{D} + \overline{C}\,\overline{D}$$

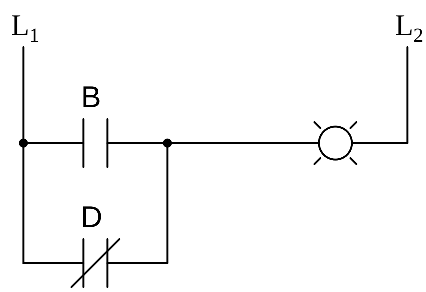


Although the relay circuit shown above does satisfy the minimal SOP Boolean expression, there is a way to make it simpler yet.

Answer 17

Simple expression and relay circuit:

$$B + \overline{D}$$



Conclusion

In addition to their practical applications, Karnaugh maps and binary arithmetic also have theoretical implications. For example, the study of Karnaugh maps can lead to a deeper understanding of boolean algebra, which forms the basis for digital logic design. Similarly, the study of binary arithmetic provides insight into the underlying principles of computer architecture and the organization of data in digital systems.

Moreover, the use of Karnaugh maps and binary arithmetic has also evolved over time with the advancements in technology. For instance, with the rise of programmable logic devices and field-programmable gate arrays (FPGAs), designers can now implement complex digital systems using high-level programming languages and design tools. This has made the design process easier and more accessible for individuals with limited background in digital electronics.

In conclusion, Karnaugh maps and binary arithmetic are crucial concepts in digital electronics and computer science. They provide a powerful toolset for understanding, designing, and implementing digital systems and continue to play an important role in the field. Whether you are a student, a researcher, or an engineer, it is important to have a solid understanding of these concepts in order to be successful in the digital age.