



A8.2 Circuits, expressions and truth tables

Boolean algebra and logic circuits · A level · OCR H446 1.4.3, AQA 7517

4.6.4.1, Eduqas A500QS 1.2 · about 20 min

Name _____

Class _____

Date _____

What this lesson is about

Reading and drawing circuits, defining a problem in Boolean logic, and sum of products from a truth table.

- From circuit to expression
- From expression to circuit
- From expression to truth table
- Defining a problem with Boolean logic
- From truth table to expression: sum of products

Questions

6 marks in all

1. $Q = \neg(A \vee B) \vee (B \wedge C)$. $A = 0$, $B = 1$ and $C = 0$. What is Q ? [1 mark]

2. For how many of the 8 input rows is $Q = \neg(A \vee B) \vee (B \wedge C)$ equal to 1? [1 mark]

3. "The alarm sounds if the robot has bumped (K), or if it is close (C) while the battery is low (L)." Which expression matches? [1 mark]
 - ☐ A $K \vee (C \wedge L)$
 - ☐ B $(K \vee C) \wedge L$
 - ☐ C $K \wedge C \wedge L$
 - ☐ D $K \vee C \vee L$
4. A truth table for A, B and C has $Q = 1$ only on the row $A=1$ $B=0$ $C=1$. Write its minterm in OCR notation, with the letters in the order A, B, C. [1 mark]

5. How many gates does the circuit for $(A \vee B) \wedge \neg C$ need? [1 mark]
 - ☐ A 3
 - ☐ B 2
 - ☐ C 4
 - ☐ D 5
6. On a circuit diagram, what does a dot where two wires meet show? [1 mark]
 - ☐ A The wires are connected (a junction)
 - ☐ B The wires cross without connecting
 - ☐ C A NOT gate
 - ☐ D The output of the circuit

The task: truth table to expression

Write `sum_of_products(outputs)`. Its input `outputs` is a list of eight integers, each 0 or 1: the Q column of a truth table for inputs A, B and C, with the rows in binary order, so `outputs[0]` is the row A=0 B=0 C=0 and `outputs[7]` is A=1 B=1 C=1. It returns a string: `Q =` followed by the minterms joined with `OR`. Each minterm is in brackets, lists A, B and C in that order joined with `AND`, and writes an input that is 0 in that row as `NOT` and a space before the letter. If no row is 1, it returns `Q = 0`. For example, `[0, 0, 1, 0, 0, 0, 0, 1]` gives `Q = (NOT A AND B AND NOT C) OR (A AND B AND C)`. Print the result for these three tables, one per line, in this order: `[0, 1, 1, 1, 1, 1, 1, 1]`, then `[0, 0, 1, 0, 0, 0, 1, 1]`, then `[0, 0, 0, 0, 0, 0, 0, 0]`.

```
# the two lines every program starts with: the commands, then the robot
from bugbot import *
connect()

def sum_of_products(outputs):
    return "Q = "

print(sum_of_products([0, 1, 1, 1, 1, 1, 1, 1]))
print(sum_of_products([0, 0, 1, 0, 0, 0, 1, 1]))
print(sum_of_products([0, 0, 0, 0, 0, 0, 0, 0]))
```

Plan your program here, then type it in and press Run.



Do it on the robot

www.bugbotlab.com/learn/a8-2-circuits-and-expressions/

The simulator checks it and tells you when it passes. Nothing to install, no account.

Challenges

1. The first table gives seven minterms. What short expression has that truth table? What does that tell you about sum of products?
2. Extend `sum_of_products` to any number of inputs, taking the variable names as a second parameter.
3. Write the alarm expression $K \vee (C \wedge L)$ in AQA notation, draw its circuit, and use your function to print its sum of products form.