

GATE Question Paper 2010, PH Question Number 41

Logic Circuit Comparison

Question: For any set of inputs A and B , the given circuits produce the same output, except one. Which one is it?

1. (A) Expression: $(A \oplus B) \cdot B'$

A	B	$A \oplus B$	B'	$(A \oplus B) \cdot B'$
0	0	0	1	0
0	1	1	0	0
1	0	1	1	1
1	1	0	0	0

2. (B) Expression: $A \cdot B'$

A	B	$A \cdot B'$
0	0	0
0	1	0
1	0	1
1	1	0

3. (C) Expression: $A \cdot B' + B' \cdot A \cdot B$

Note that $B' \cdot A \cdot B = 0$, since $B' \cdot B = 0$. So this simplifies to $A \cdot B'$, same as (B).

A	B	B'	$A \cdot B'$	$A \cdot B' \cdot B$	Result
0	0	1	0	0	0
0	1	0	0	0	0
1	0	1	1	0	1
1	1	0	0	0	0

4. (D) Expression: $A' + B$

A	B	A'	$A' + B$
0	0	1	1
0	1	1	1
1	0	0	0
1	1	0	1

Conclusion

The outputs of circuits (A), (B), and (C) are all the same: [0, 0, 1, 0]. However, the output of circuit (D) is: [1, 1, 0, 1], which is different.

Therefore, the answer is: (D).

Brief Discussion

The circuit implements and compares four logic expressions:

- Expression A: $(A \oplus B) \cdot B'$
- Expression B: $A \cdot B'$
- Expression C: $A \cdot B' + A \cdot B \cdot B'$ (simplifies to B)
- Expression D: $A' + B$

All expressions except (D) behave identically for inputs A, B . The setup uses LEDs to indicate the output of each expression for real-time validation.

Abstract

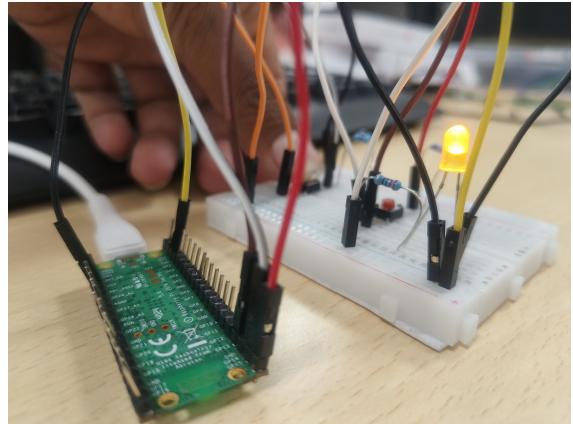
This document presents the practical implementation and comparison of four Boolean logic expressions using the Arduino Uno board. It includes hardware requirements, pin mappings, circuit connections, upload steps, and observed results through LED outputs.

Implementation using Arduino Uno

Hardware Requirements:

S.No	Component
1	Arduino Uno Board
2	Breadboard
3	Push Buttons (2)
4	LEDs (4)
5	Resistors: 220Ω , $10k\Omega$
6	Jumper Wires
7	USB Cable

Table 1: Arduino Hardware Components



Pin Connections:

Component	Arduino Pin
A (Button 1)	Digital 2
B (Button 2)	Digital 3
LED for Expr A: $(A \oplus B) \cdot B'$	Digital 8
LED for Expr B: $A \cdot B'$	Digital 9
LED for Expr C: $A \cdot B' + A \cdot B \cdot B'$	Digital 10
LED for Expr D: $A' + B$	Digital 11
GND	GND
VCC	5V

Table 2: Pin Mapping for Arduino Uno

Upload Steps

Upload Steps via Mobile:

1. Connect Arduino Uno to mobile via OTG cable.
2. Open the ArduinoDroid app.
3. Select "Arduino Uno" from the board list.
4. Paste or open the code implementing all 4 logic expressions.
5. Tap on "Compile" and then "Upload."
6. Assemble the circuit on a breadboard.
7. Press button combinations and observe each LED for expression output.

Observations

A	B	Expr A	Expr B	Expr C	Expr D
0	0	0	0	0	1
0	1	0	0	0	1
1	0	1	1	1	0
1	1	0	0	0	1

Table 3: Observed Truth Table using LEDs on Arduino Uno

Conclusion

- Expressions A, B, and C behaved identically and gave output high only for input $A = 1, B = 0$.
- Expression D produced high output for all inputs except when $A = 1, B = 0$.
- The Arduino Uno circuit accurately reflected theoretical behavior through visual LED output, validating logic gate design.

Implementation using Raspberry Pi Pico 2 W

Hardware Requirements:

S.No	Component
1	Raspberry Pi Pico 2 W
2	Breadboard
3	Push Buttons (2)
4	LEDs (4)
5	Resistors: 220Ω , $10k\Omega$
6	Jumper Wires
7	Micro USB Cable

Table 4: Pico 2 W Hardware Components

Pin Connections:

Component	Pins
A (Button 1)	GP14
B (Button 2)	GP15
LED for Expr A: $(A \oplus B) \cdot B'$	GP13
LED for Expr B: $A \cdot B'$	GP12
LED for Expr C: $A \cdot B' + A \cdot B \cdot B'$	GP11
LED for Expr D: $A' + B$	GP10
GND	GND
VCC	3.3V

Table 5: GPIO Pin Mapping for Pico 2 W

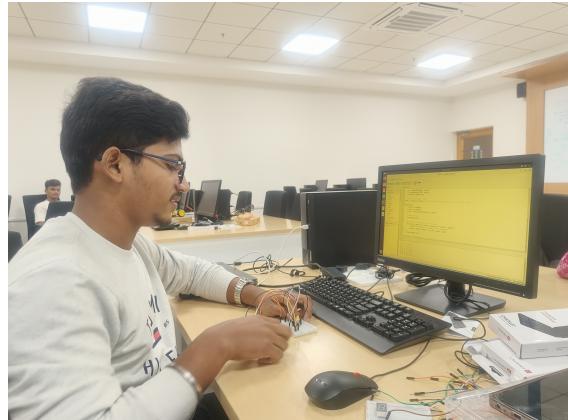


Figure: Circuit connected to Raspberry Pi Pico 2 W with 4 LED outputs

Upload Steps

Upload Steps via Mobile:

1. Connect Pico 2 W to mobile using OTG while holding BOOTSEL.
2. Copy MicroPython firmware (.uf2) to the board.
3. Open the MicroREPL or uPyCraft app on mobile.
4. Connect to the Pico 2 W and paste/upload the MicroPython code.
5. Assemble the circuit on the breadboard as per the pin mapping.
6. Press the buttons to test all logic expressions through LED outputs.

Observations

A	B	Expr A	Expr B	Expr C	Expr D
0	0	0	0	0	1
0	1	0	0	0	1
1	0	1	1	1	0
1	1	0	0	0	1

Table 6: Observed Truth Table on Pico 2 W

Conclusion

- The Raspberry Pi Pico 2 W was successfully used to implement and verify all four Boolean expressions.
- Expressions A, B, and C produced identical outputs, while Expression D differed.
- The experiment confirms theoretical logic through practical validation using MicroPython on Pico 2 W.

GitHub Repository: https://github.com/ashok-kumar-reddy-17/Ashok_FWC