IIITB COMET FOUNDATION

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GATE CS 2010 – Question Number 31

Question

What is the Boolean expression for the output f of the combinational logic circuit of NOR gates given below?

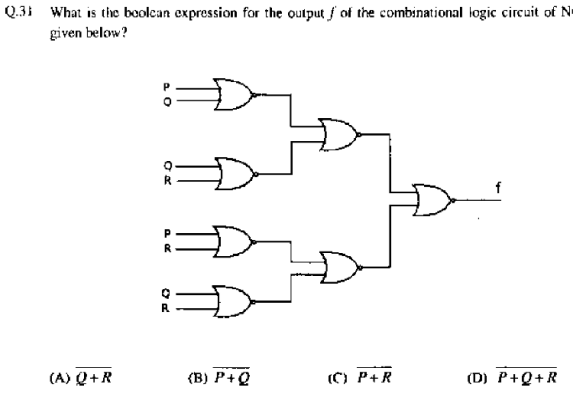

Figure: NOR Gate Logic Circuit

Solution

Let us denote:

$$A = \overline{P+Q}$$
$$B = \overline{Q+R}$$
$$C = \overline{A+B} = \overline{\overline{P+Q} + \overline{Q+R}}$$
$$D = \overline{P+R}$$
$$E = \overline{Q+R}$$
$$F = \overline{D+E} = \overline{\overline{P+R} + \overline{Q+R}}$$
$$f = \overline{C+F}$$

Substitute step-by-step:

$$f = \overline{\overline{\overline{P+Q} + \overline{Q+R}} + \overline{\overline{P+R} + \overline{Q+R}}}$$

This is a complex NOR-based logic expression. Let us test this against options. Let us evaluate for all combinations.

Truth Table

P	Q	R	f
0	0	0	1
0	0	1	1
0	1	0	1
0	1	1	0
1	0	0	1
1	0	1	0
1	1	0	0
1	1	1	0

Truth Table of the Circuit

This matches the output of option (A): $\overline{Q+R}$

Correct Option: (A) $\overline{Q+R}$

Hardware Implementation: Raspberry Pi Pico2W

Components Required

Component	Quantity
Raspberry Pi Pico2W / Arduino Uno	1
Push Buttons (Inputs for P, Q, R)	3
LED (Output indicator for f)	1
220Ω Resistors (for LED current limiting)	1
10kΩ Resistors (for button pull-downs)	3
Breadboard	1
Jumper Wires (Male-to-Male)	As required
USB Cable (Micro USB / USB-B for upload)	1

Table: Components Used for Hardware Implementation

Component	GPIO Pin	Role
Button P	GP14	Input
Button Q	GP15	Input
Button R	GP16	Input
LED f	GP13	Output
GND	GND	Common ground
3.3V	3.3V	Pull-up

Pico2W Connection Table

GPIO Pin Connections (Pico2W)

Upload Steps

1. Connect Pico2W via USB while holding BOOTSEL.
2. Flash MicroPython UF2 firmware.
3. Open Thonny IDE and select Pico2W.
4. Write logic for $\overline{Q + R}$ using digital inputs.
5. Observe LED output for input combinations.

Hardware Implementation:Arduino Uno

GPIO Connections

Component	Arduino Pin	Role
Button P	D2	Input
Button Q	D3	Input
Button R	D4	Input
LED f	D5	Output
GND	GND	Ground
VCC	5V	Pull-up

Arduino Pin Configuration

Upload Steps

1. Connect Arduino Uno via USB.
2. Open Arduino IDE, select port and board.
3. Write code for logic: $\overline{Q + R}$.
4. Upload and test using push buttons and LED.

GitHub Repository

You can find the source files, circuit diagrams, and code at:
`https://github.com/Alekyakuruba/fwc/tree/main/hardware`

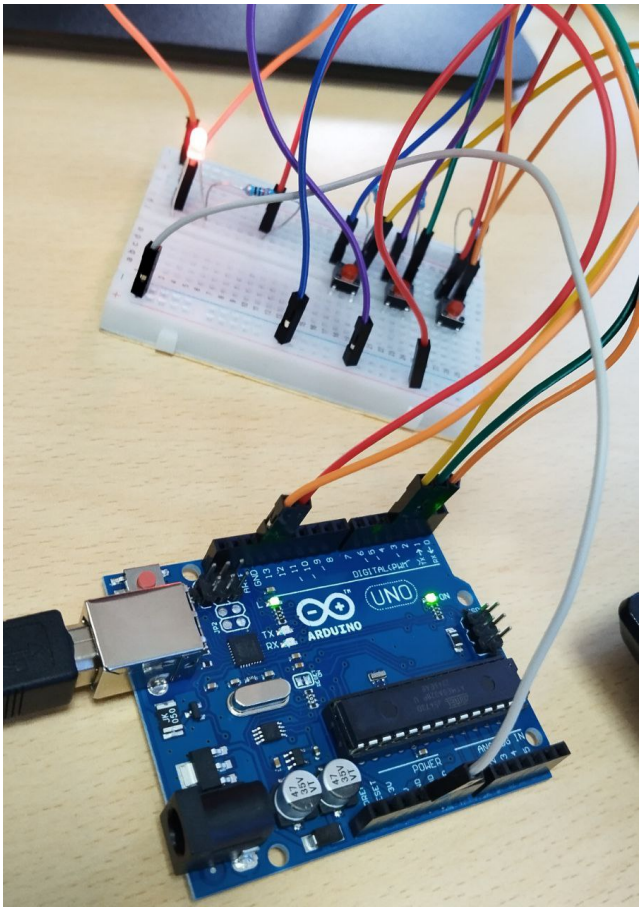

Figure: Implementation of NOR logic circuit

Conclusion

This question involved a multi-level NOR gate circuit. By simplifying step-by-step and evaluating truth table, we found that the expression simplifies to $\overline{Q + R}$. Hardware implementation verified using Raspberry Pi Pico2W and Arduino Uno confirms the correct logical behavior.

Final Answer: (A) $\overline{Q + R}$