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GATE CS 2010 – Question Number 9

Question

The Boolean expression for the output f of the multiplexer shown below is:

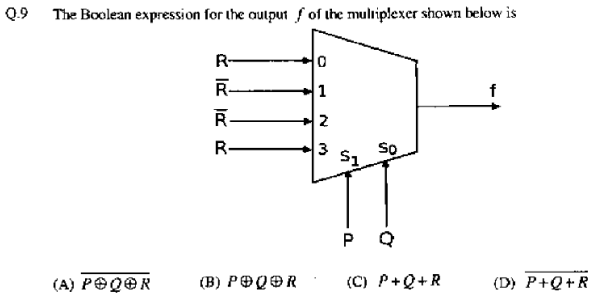

Figure: 4x1 Multiplexer with inputs and select lines

Solution

Given a 4x1 multiplexer:

- Select lines: $S_1 = P$, $S_0 = Q$
- Inputs:

$$I_0 = R$$
$$I_1 = \overline{R}$$
$$I_2 = \overline{R}$$
$$I_3 = R$$

Using MUX expression:

$$f = I_0\overline{P}\overline{Q} + I_1\overline{P}Q + I_2P\overline{Q} + I_3PQ$$

Substitute inputs:

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

This matches the expression:

$$f = P \oplus Q \oplus R$$

Correct Option: (B) $P \oplus Q \oplus R$

Truth Table

P	Q	R	f
0	0	0	0
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	1

Truth Table of the MUX Output

Hardware Implementation: Pico2W

Components Required

Component	Qty
Raspberry Pi Pico2W	1
Push Buttons (P, Q, R)	3
LED (Output f)	1
Resistors (220 ohm)	4
Breadboard + Jumper Wires	-

Pico2W Components

GPIO Pin Connections (Pico2W)

Component	GPIO Pin	Function
Button P	GP14	Input
Button Q	GP15	Input
Button R	GP16	Input
LED f	GP13	Output
Resistors	10k	Stable Low
LED Ressitor	220Ω	Protects LED
Common Ground	GND	Ground
Power Supply	3.3V	Logic high supply

Table: Raspberry Pi Pico2W Pin Configuration

Uploading Code to Pico2W

1. Connect the Raspberry Pi Pico2W to your computer using a USB cable while holding the **BOOTSEL** button.
2. The board appears as a USB drive on your computer.
3. Download and drag the MicroPython `.uf2` firmware file to the Pico's USB drive.
4. Open the **Thonny IDE** on your computer.
5. In Thonny, go to `Tools` → `Interpreter` and select **MicroPython (Raspberry Pi Pico)**.
6. Write or paste your Python code (logic implementation).
7. Click **Run** or press `F5` to upload and execute the code on Pico2W.
8. Observe the output on the LED based on button inputs.

Hardware Implementation:Arduino Uno

GPIO Pin Connections: Arduino Uno

Component	Arduino Pin	Direction
Push Button P	D2	Input
Push Button Q	D3	Input
Push Button R	D4	Input
LED (Output f)	D5	Output
GND (Common Ground)	GND	Power
VCC (5V)	5V	Power

Table: Arduino Uno Pin Configuration for MUX Logic

Uploading Code to Arduino Uno

1. Connect the Arduino Uno to your computer using a USB cable.
2. Open the **Arduino IDE** (download from `arduino.cc` if not installed).
3. Select the correct board and port:
   - Go to `Tools` → `Board` → **Arduino Uno**
   - Then `Tools` → `Port` → Select your device port
4. Write or paste your logic code (e.g., for NOR gate or expression implementation).
5. Click the **Upload** button (right arrow icon) or press `Ctrl+U`.
6. Wait for "Done uploading" message.
7. Test using push buttons and observe output on the LED.

GitHub Repository

`https://github.com/Alekyakuruba/fwc/tree/main/hardware`

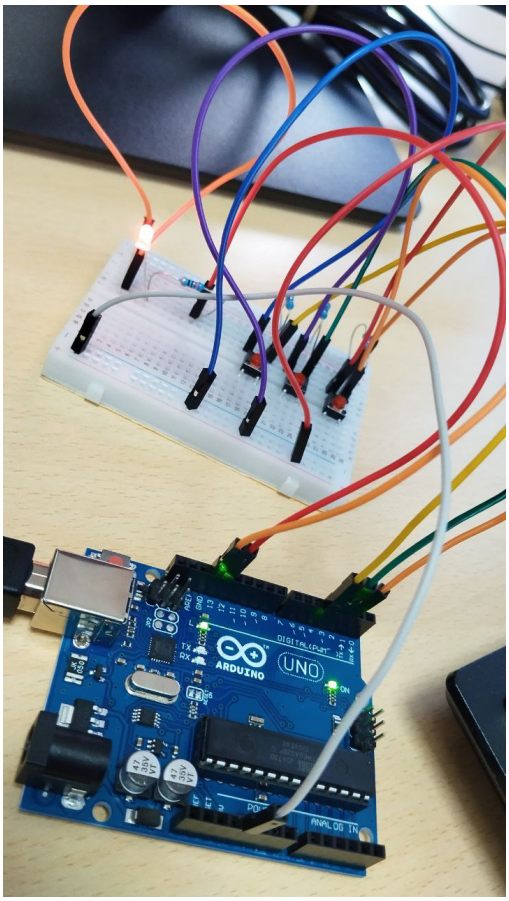

Figure: 4x1 Multiplexer implememtation

Conclusion

This problem involved a 4x1 MUX with binary select inputs P and Q. Substituting MUX inputs and evaluating the expression gives:

$$f = P \oplus Q \oplus R$$

The expression is confirmed by constructing the truth table and verifying with all options. Hardware implementation is feasible using both Pico2W and Arduino Uno.

Final Answer: (B) $P \oplus Q \oplus R$